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TESTING OF CAPSULES USED IN RADIOGRAPHY CAMERAS

by

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TESTING OF CAPSULES USED IN RADIOGRAPHY CAMERAS

ABSTRACT

The C-182 non-radioactive (dummy) radiography capsules manufactured by Atomic Energy of Canada Limited were mechanically tested by performing a prescribed number of cycles under preset conditions in a Model 100-3 Pneumat-A-Ray radiography camera. The capsules were observed throughout the cycling trials and tested for changes in dimension, weight, and leakage. After completion of the prescribed cycling trials each capsule was further tested for potential leakage by dye penetrant examination, sectioned at the equator and each half tested by dye penetrant examination, then sectioned again longitudinally, and metallurgically examined.

The results indicate that the capsules cycled under typical field conditions can become significantly deformed, and that deformation is generally related to the number of cycles that the capsules undergo. The deformation occurs almost exclusively on the end of the capsule entering the camera first.

When the headhose cushion is removed the deformation occurs on both ends of the capsule.

The deformation is related only to the pneumatic operating mode of the camera and there was no evidence for deformation when the camera was used under pipeline mode of operation.

The only leak observed in this series of tests was not related to the deformed end of the capsule, but rather to the weld end of the capsule when the non weld end of the capsule was deformed from entering the camera. The leak was shown by dye penetrant examination and by photomicrographs of the cross section of the affected capsule.

RÉSUMÉ

Les capsules de radiographie n° C-182 fabriquées par L'Énergie Atomique du Canada, Limitée ont été mises à l'épreuve mécaniquement en étant soumises à un nombre prévu de cycles sous des conditions prédéterminées dans un appareil de radiographie de modèle 'Pneumat-A-Ray' n° 100-3. Les capsules ont été observées tout au long des épreuves cycliques et leurs variations de dimensions, de poids et d'étanchéité ont été notées. Après les épreuves cycliques prévues, chaque capsule a été soumise à un examen d'étanchéité à l'aide d'une teinture pénétrante. À cet effet, elles ont été sectionnées en plein centre et chaque moitié a fait l'objet d'un examen par teinture, puis a été sectionnée longitudinalement et soumise à un examen métallurgique.

Les résultats indiquent que les capsules soumises à des cycles s'approchant des conditions réelles d'utilisation peuvent être considérablement déformées, selon le nombre de cycles appliqués, en général. La déformation ne se produit presque exclusivement qu'au bout de la capsule qui est introduit le premier dans l'appareil de radiographie.

Quand le coussin absorbant est enlevé, la déformation se produit aux deux bouts de la capsule.

La déformation n'est reliée qu'au mode opérationnel pneumatique et il n'existe aucune preuve de déformation lorsque l'appareil de radiographie a été utilisé selon le mode pipeline.

La seule fuite observée au cours de ces épreuves n'était pas reliée au bout déformé de la capsule, mais plutôt au bout soudé de la capsule quand le bout non soudé était déformé du fait d'avoir pénétré dans l'appareil de radiographie. La fuite a été démontrée par teinture pénétrante et aussi par photomicrographies de la coupe transversale de la capsule endommagée.

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MECHANICAL TESTING OF CAPSULES USED IN RADIOGRAPHY CAMERA

A. INTRODUCTION

1. Background Information

Several sealed sources, called capsules, used in Pneumat-A-Ray radiography cameras were recently found to have developed leaks during field use. Because of the potentially hazardous situation that could arise as a result of a leaking capsule, it is essential that the cause of the leaks be determined.

2. Objective

The objective of this project is to determine the cause of capsule leakage.

3. Scope

The project entitled "The Mechanical Testing of Capsules Used in Radiography Cameras" (AECB Number E1103410500) was performed by the Alberta Research Council, Materials and Testing Department during the months of April through November, 1985. The project consisted of a series of cycling tests of inactive C-182 radiography capsules in Pneumat-A-Ray Model 100-3 radiography cameras. The capsules were cycled to a prescribed set of conditions as specified in the work statement. The capsules were weighed, bubble tested, measured and photographed at prescribed intervals during the cycling. At the completion of cycling the capsules were dye penetrant tested, and metallurgically examined to determine the effect that the cycling had on the capsule.

B. TESTING

1. Test Conditions

The capsules were cycled under conditions that resembled as closely as possible actual field use or as prescribed in the work statement. Consideration was given to the factors of air and vacuum pressure in the headhose, headhose length, camera position and pumping operation.

1.1 Field Study

Mr. Leo Spencer of Spencer Manufacturing Ltd. discussed radiography equipment and its use with Alberta Research Council personnel. The Model 100-3 pneumatic cameras are designed and manufactured at Spencer Manufacturing Ltd. Drawing 1 (Appendix) shows a sketch of a Model 100-3 Pneumat-A-Ray camera. Observations of radiography operations were made at Rivest Brothers Enterprises Ltd., and the personnel there consulted about normal field operations.

A demonstration of a standard radiography operation was performed at Rivest Brothers Enterprises Ltd. using their equipment, which was originally purchased from Spencer Manufacturing Ltd. It was affirmed by the personnel involved that the demonstration was typical of normal operation.

Two radiographers, Mr. Moe Shandro and Mr. Barry Rasmussen, operated three different pumps while headhose air pressures were being measured. Two of the pumps were approximately one year old, and the third was seven years old. These were attached to a model 100-3 camera, and a 12.2 meter straight headhose in the same manner as described in the DSS File: 55SS.87055-4-4077 work statement. The air pressure in the headhose was measured by connecting a 150 kPa pressure transducer to the camera-headhose connector. A chart recorder, wired to the transducer, recorded the output pressures.

A total of 65 pressure measurements were taken with the pumps operated at both high stroke speed and normal operation. For normal operation by Rivest Brothers Enterprises Ltd. radiographers, the average headhose pressure near the camera was determined to be 38 kPa. The maximum pressure recorded was 62 kPa. The radiographers stated that the maximum stroke speed would seldom occur in the field.

Normal radiography operation uses the field pump to move the capsule from within the camera to the end of the headhose for a radiographic exposure, then returning the capsule to the camera again using the field pump. Radiographers often use a quick, short stroke to get the capsule out of the camera, followed by a longer stroke to move the capsule down the head hose. During the operational demonstration, the radiographers used a single pump stroke, which was sufficient to move the capsule to the end of the headhose in all of the demonstration trials. It was noted by one of the radiographers that a double pressure or vacuum stoke may be required in some field instances to make the capsule move the entire length of headhose.

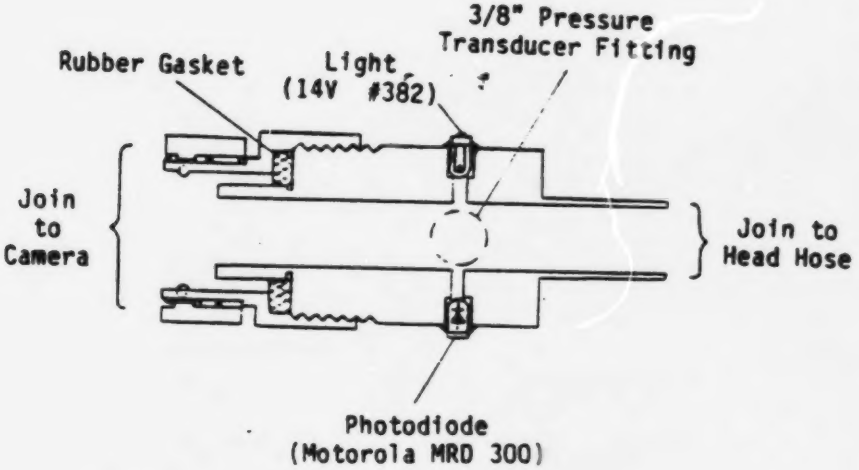
At a later date, the vacuum pressure exerted by the field pumps was measured at the Alberta Research Council. Mr. Leo Spencer operated the pump at a measured vacuum pressure of between 51 and 57 kPa (15 and 17 inches of mercury).

2. Test Apparatus

Two Pneumat-A-Ray Model 100-3 pneumatic cameras (serial numbers 094 and 095), complete with headhoses, pumps and attachments were rented from Spencer Manufacturing Ltd. Slight adjustments were made at the camera connection and headhose end cap to accomodate the pressure transducer and sensors. Figures 1 and 2 show the modified camera connector and head hose end cap respectively. The headhoses provided were manufactured by Fairview Fittings (SAE 100R3). The sizes of the headhoses were 9.5mm (3/8 inch) inside diameter and 12.2 meters in length. The field pumps used to drive the capsule consisted of an 127mm diameter piston with leather seals with a 280mm stroke. A 12.7 mm diameter rubber hose connected the field pumps to the cameras. To automate the system, a pneumatic cylinder was connected to the handle of the piston which operated the field pumps. A 689 kPa (100 psi) air supply was regulated and directed to the pneumatic cylinders by a three way switching valve. The three way valve controlled the action of pneumatic cylinder which in turn actuated the field pump to produce pressure (downstroke) and vacuum (return stroke), when the capsule was sensed to be in the camera and at the end of the headhose respectively. The automated cycling system is shown in Figure 3 and Photographs 1 and 2.

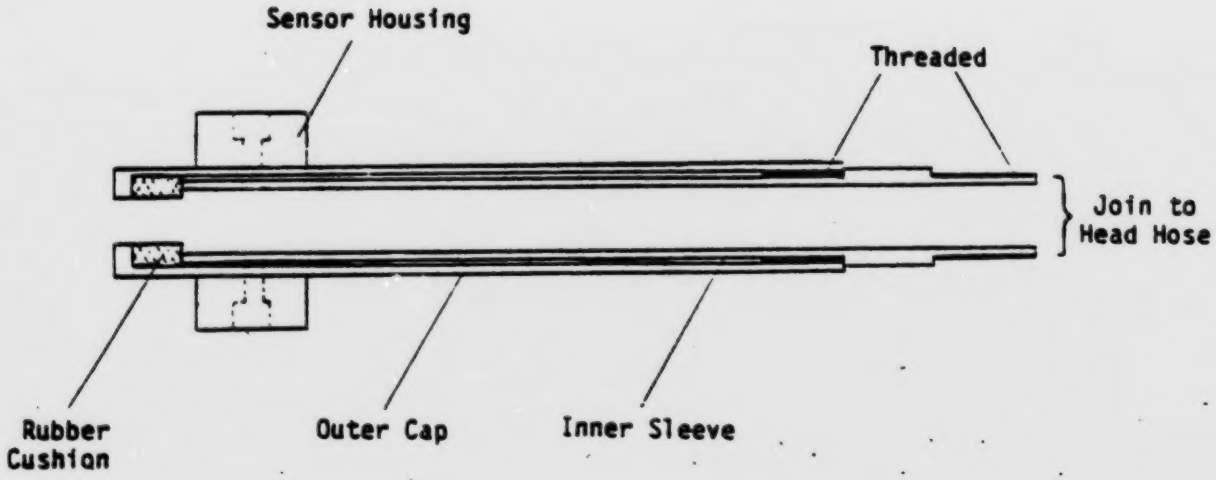
The automated test system was observed by Mr. Leo Spencer and Mr. Ken Valens.

FIGURE 1: CAMERA - HEADHOSE CONNECTION WITH PHOTODIODE SENSOR AND PRESSURE TRANSDUCER FITTING

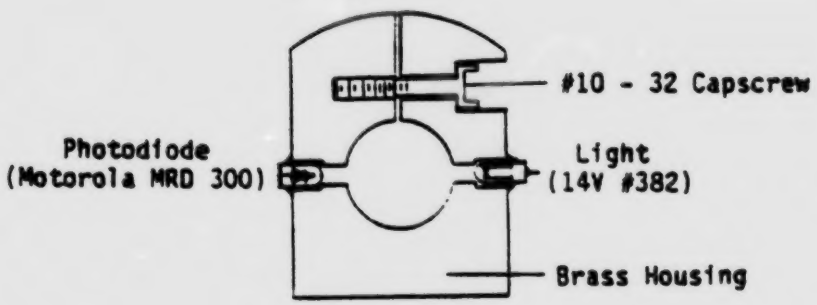


SCALE 1:1

FIGURE 2: HEADHOSE END CAP WITH PHOTODIODE SENSOR



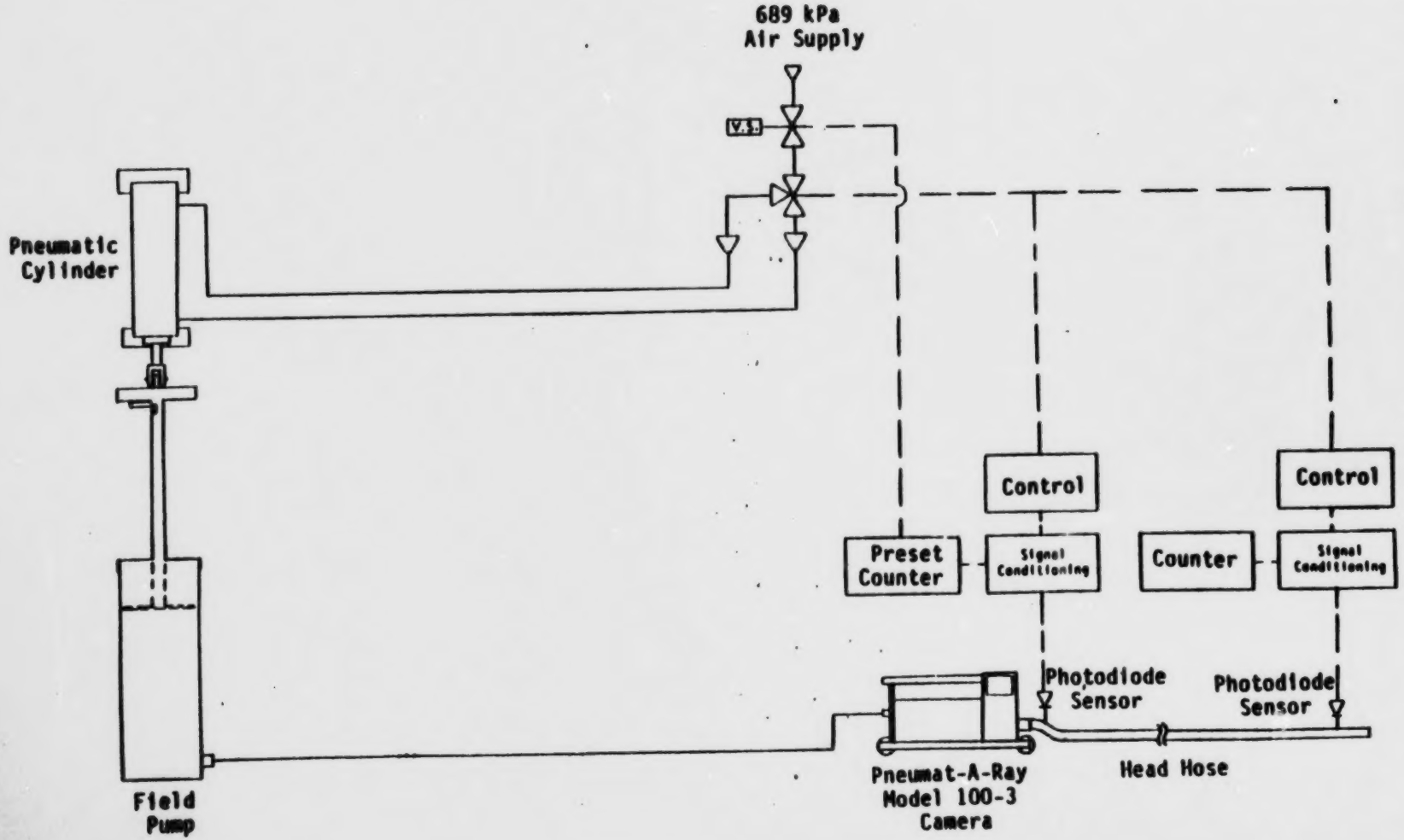
SCALE 1:1



PHOTODIODE SENSOR DETAIL

SCALE 1:1

FIGURE 3: SCHEMATIC DIAGRAM OF CAPSULE TESTING APPARATUS



Photograph 1: Headhose Assembly and Control Unit

Photograph 2: Mechanical Test Apparatus Showing the Pumps and the Pump Control Mechanisms

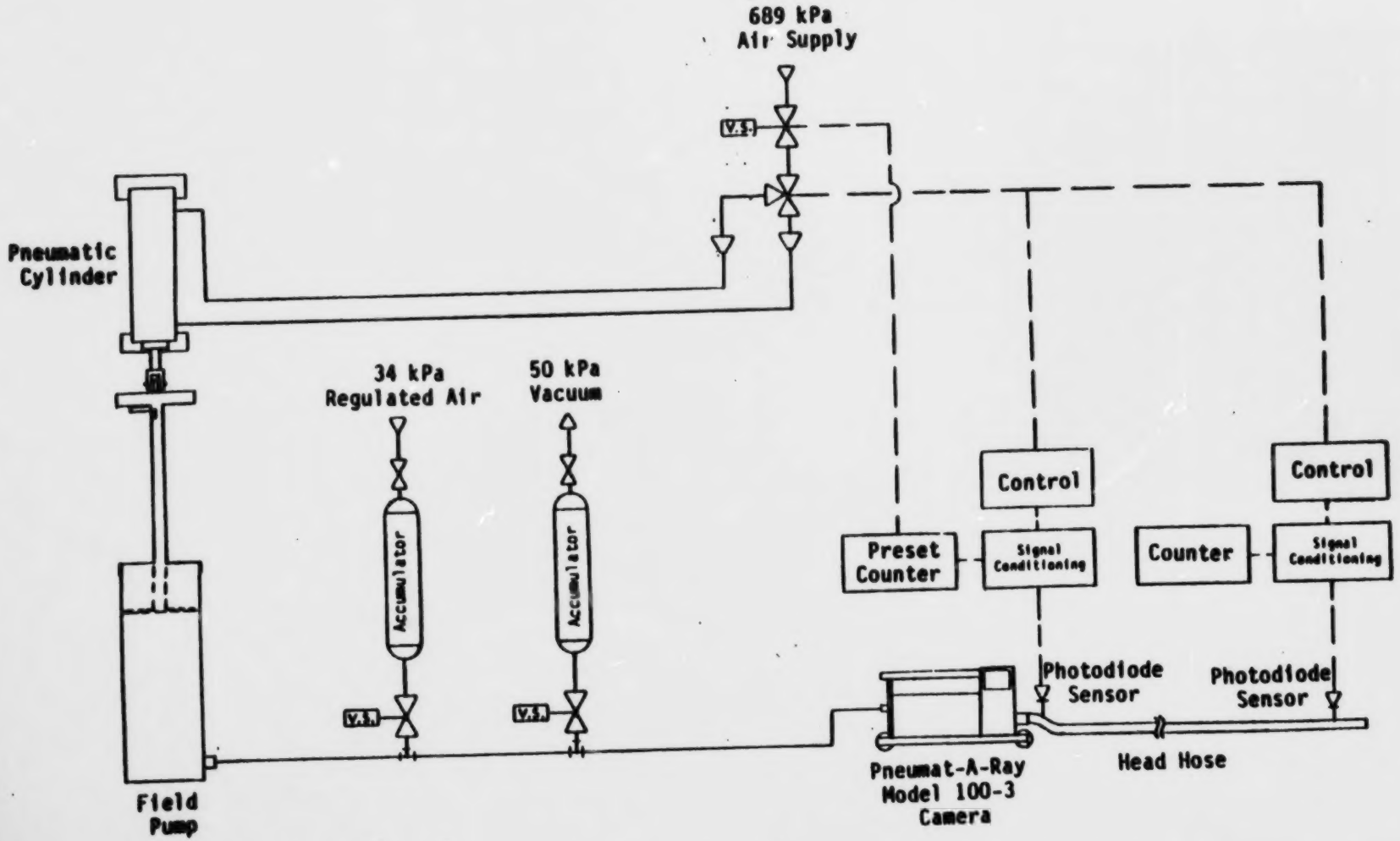
The system allowed for a single stroke of the field pump for each cycle, since this had been sufficient during the demonstration trial. Although a single stroke worked for many cycles, it did not work reliably enough for an unattended automated system since the capsule did not always reach the end of the headhose, or return to the camera, and the system proved to be too inconsistent for extensive unattended automated cycling.

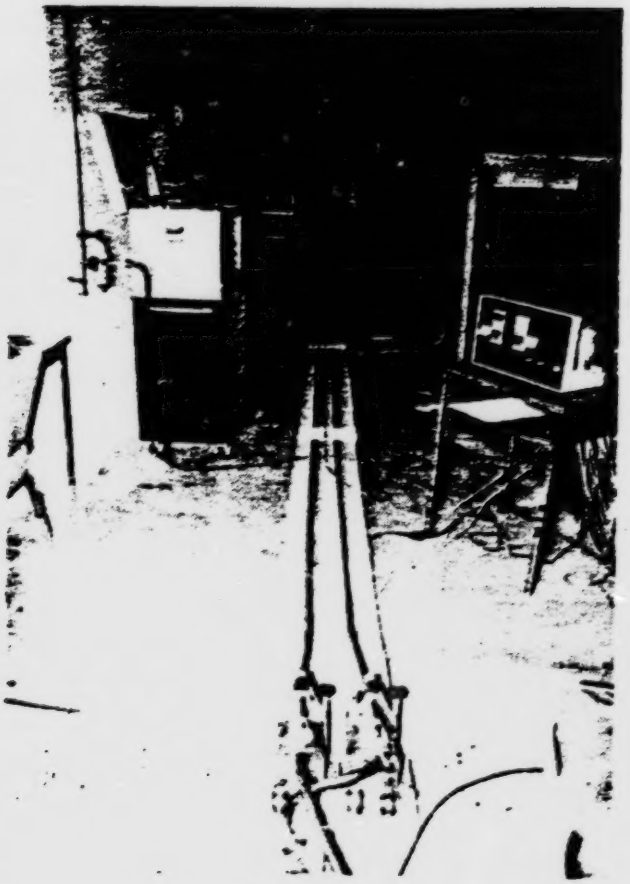
Since the field pumps did not operate consistently at the measured field pressure and vacuum, ballast accumulators were added to assist the pumps. The pressure and vacuum ballast accumulators were opened and closed by solonoid valves. A pressure regulator was used to maintain the air in the accumulators at a constant pressure of 34 kPa (5 psi). Vacuum pumps continuously evacuated the vacuum accumulators. On the downstroke of the field pump, the pressure accumulator opened to allow air at the measured typical pressure to assist the pump to carry the capsule to the end of the headhose. When the capsule triggered the headhose sensor, the pressure accumulator closed, and the vacuum accumulator opened to assist the field pump to draw the capsule back into the camera. Once the capsule reached the sensor at the camera, the counter was advanced and the process repeated. A time delay after each cycle was built into the system to allow the pressure in the pumps, camera and headhose to equalize. Figure 4 is a diagram of the ballasted system. Photograph 3 and 4 show the actual ballasted assembly.

Mr. Leo Gourgon and Mr. Ross Brown of Atomic Energy Control Board observed the automated ballasted system in operation.

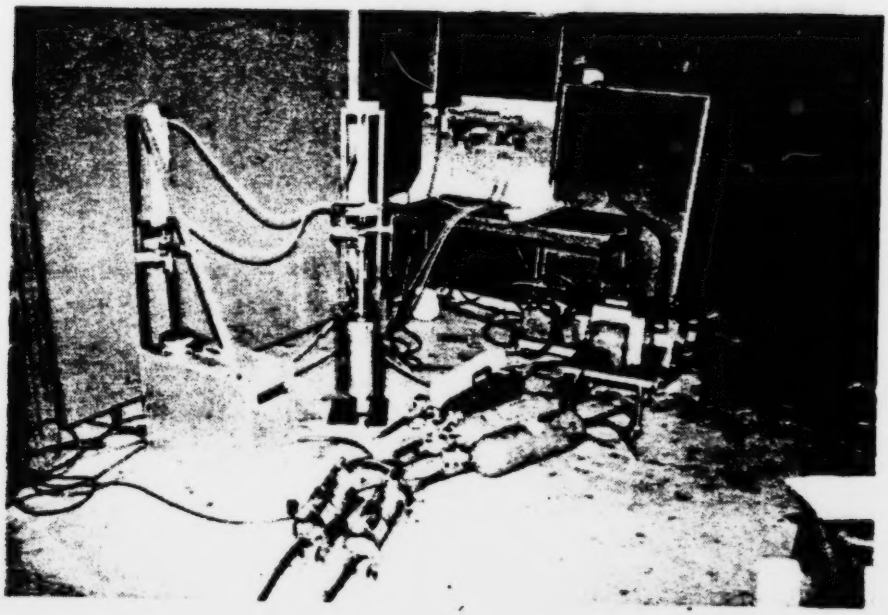
The use of the capsule in pipeline mode was tested using the teleflex cable provided without alterations. A pneumatic cylinder was used to automatically move the cable inside its housing. Mechanical microswitches at either end of the stroke of the pneumatic cylinder were used to reverse the direction of the pneumatic cylinder and to advance the counter after each cycle. A photograph of the system is shown in Photograph 5.

FIGURE 4: SCHEMATIC DIAGRAM OF CAPSULE TESTING APPARATUS WITH PRESSURE AND VACUUM ACCUMULATORS

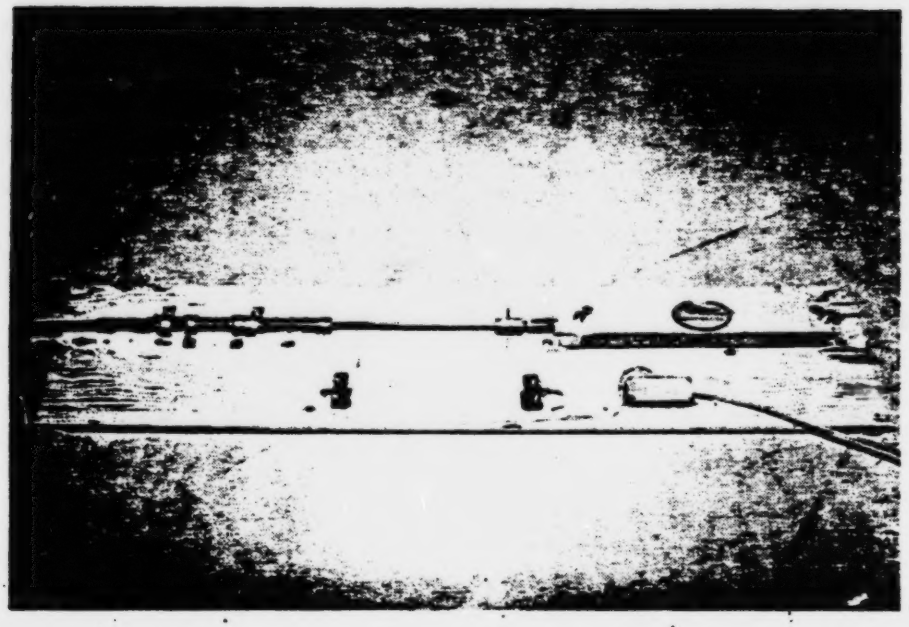




Photograph 3: Headhose Assembly



Photograph 4: Mechanical Test Apparatus Showing the Pumps, the Control Mechanism and the Accumulators



Photograph 5: The Push Pull Assembly for the Pipeline Mode of Operation

3. Capsule Testing

Upon receipt of the capsules, each was measured, weighed, bubble tested, radiographed and photographed. The capsules were randomly assigned to each cycling test as they appeared in the work statement by using a random number generator as shown in Table 1. Additional information with respect to the capsule design and manufacturing data was supplied by Atomic Energy of Canada Limited and is shown in the Appendix.

Four capsules were sectioned longitudinally to metallurgically examine the penetration of the welds (capsule serial numbers 2078, 2085, 2091). One capsule was sectioned equitorially and then logitudinally (capsule serial number 2094). The equitorial sectioning permitted the examination of an intact inner capsule.

The minimum weld penetration requirement is 80%. The weld penetration is defined as the minimum weld thickness (measured from the point of intersection of the weld, cap and body to the outside surface of the weldment) divided by the minimum wall thickness of the cap. The weld penetration data is shown in Table 2.

All four welds proved to meet the penetration requirement when examined metallographically.

3.1 Cycling

Normal orientation was defined to be when the capsule was cycled with the weld end toward the camera, as recommended by Mr. T. J. Simpson of Atomic Energy of Canada Limited and by consensus of several users.

The cycling tests were initiated by placing the capsule in the camera in the desired orientation and adjusting the preset counter for the prescribed number of cycles as set down in the work statement and starting the system. After completion of the specified number of cycles, the capsule was removed from the camera and visually inspected, measured, weighed, bubble tested and photographed.

The standard tests were performed in normal orientation with a straight 12.2 meter headhose and an air pressure of approximately 38 kPa. The headhose cushion was maintained in good condition for the cycling tests requiring a cushion in the headhose. The air pressure varied somewhat due to the changing dimensions of the capsule as well as variations in the field pump pressure. The vacuum pressure was normally slightly lower than the field measure value of 15 kPa gauge.

Six capsules were tested in typical field operating conditions and normal orientation; three to 40,000 cycles (capsules serial numbers 2074, 2076, and 2088), two to 80,000 cycles (capsules serial numbers 2087, and 2093), and one to 200,000 cycles (capsule serial number 2081, cycled to only 160,200 cycles).

TABLE 1

RANDOM SELECTION OF CAPSULES - USING RANDOM NUMBER GENERATOR TI-59

CAPSULE NO.	SER. NO.	RANDOM ORDER TO TEST
2	2074	4
3	2076	16
4	2077	8
5	2078	3
6	2079	15
7	2080	13
8	2081	11
9	2082	12
10	2083	7
11	2084	14
12	2085	2
13	2086	17
14	2087	9
15	2088	5
16	2090	6
17	2091	1
18	2093	10
19	2094	18

One capsule was cycled to 40,000 cycles at typical field operating conditions and in reverse orientation (capsule serial number 2077).

One capsule was cycled to 10,000 cycles using standard air pressures with two 45 degree bends in the headhose (capsule serial number 2082).

One capsule was cycled to 40,000 cycles under typical field operating conditions without a rubber cushion in the headhose cap (capsule serial number 2079).

A capsule was cycled to 40,000 cycles with the headhose shortened to 3.05 meters. (Capsule serial number 2083). This allowed a greater vacuum to occur on the return stroke, as well as a higher pressure on the outward stroke.

Two capsules were cycled to 40,000 in the pipeline mode (capsule serial numbers 2080, and 2084); one in normal orientation (2084) and one in reverse orientation (2080).

3.2 Capsule Examination During Cycling

At the set cycle intervals as prescribed by the DSS Statement of Work, each of the capsules were examined. The height and diameter of the capsules were measured to 0.01 mm. Measurements were performed on a digital thickness micrometer. Average readings were taken at the centre of the capsule for a diameter measurement. The weight of the clean capsule was measured to 1 mg on a digital weigh scale. Photographs were taken of the weld end of the capsule as well as its side view. Photographs of both the weld and unwelded end of the capsule cycled with no headhose cushion were made.

Bubble tests were performed on the capsules as prescribed in the work statement. Approximately 450 ml of ethylene glycol was placed in a 600 ml vacuum flask, and the flask sealed with a rubber stopper. A small vacuum pump evacuated the flask for a period of at least one minute to an absolute pressure of 15 to 25 kPa to degas the solution. The capsule was then placed in the liquid to a depth of about 75mm, the flask pressure was again reduced to a pressure of 15 to 25 kPa absolute and the capsule was observed to see if a stream of gas bubbles was emanating from the capsule.

3.3 Capsule Examination After Cycling

The Capsules were all bubble tested again by placing them in degassed water held at 95° C as instructed by Mr. T. Simpson.

The capsules were dye penetrant tested before sectioning, and then sectioned at the equator and each half capsule and any intact inner capsules dye penetrant tested for defects or cracks. The sectioning at the equator was accomplished by placing the non weld end of the capsule in the collet of a lathe and using a narrow tool (0.6mm) to section at the equator. Extreme care was taken to try and prevent damage to the insert.

The capsules that were sectioned at the equator were further sectioned longitudinally by using a low speed wafering saw. The cross sections were mounted in a phenolic resin and polished to 0.05 microns. The samples were electrolytically etched (10% oxalic acid) to reveal the microstructure. The specimens were examined with a metallograph and photographs taken of the weldments and insert. The weld penetration was determined from these photographs. The photographs were examined for evidence of defects.

C. DISCUSSION

1. Deformation

In general all of the capsules that were cycled pneumatically showed some degree of deformation at the end that underwent the hard landing, either at the camera end or the unprotected headhose end.

The capsules cycled near the beginning of the project, when the cameras were new, show a different type of deformation than those cycled after the camera has been used for several thousand cycles. This suggests the possibility that either the S-tube or the S-tube stop within the camera changes shape with use.

The capsules cycled when the camera was new showed signs of deformation early in the test. For example capsule 2088 was started to be cycled May 29, 1985 and after the first 250 cycles small knicks appeared around the outside weld circumference. The capsule weld became more evenly hammered around the outside edge as the cycling progressed. With increased cycling the weld end became very rounded, mushrooming over the sides of capsule. The depression inside the weld became closed in with increased cycling and increased deformation of the capsule.

Capsules cycled later in the project, after the cameras had been used, showed no knicking around the weld (capsule serial number 2083 started September 9, 1985). The camera oriented end of the capsule deformed to a round smooth end, with no mushrooming over the sides of the capsule.

The degree of deformation was usually related to the amount of cycling, those cycled more often were generally more deformed than those cycled less often. For example, capsules 2081 cycled 160,200 times under typical field conditions and normal orientation was considerably more deformed than capsules 2093, cycled 80,000 times, and capsule 2093 in turn was generally more deformed than the similarly treated capsules 2074, 2076, and 2088 that were cycled to only 40,000 times.

Capsule serial number 2077 was cycled in reverse orientation which caused the nonweld end of the capsule to become rounded while the weld end showed little deformation. A rubber cushion in the headhose protected the weld end of the capsule from deformation.

Capsule serial number 2079 was cycled without a headhose cushion. The weld end became worn similar to those capsules tested in the normal orientation. However, because the rubber cushion was not in place to protect the nonwelded end of capsule 2079, the nonweld end became very deformed. The capsule deformation of the nonweld end progressed with the cycling to become almost cone shaped.

The capsules cycled in the pipeline mode showed little deformation and only superficial surface wear.

A comparison of capsule 2083, cycled to 40,000 cycles at maximum pressure and vacuum, to capsules 2074, 2076 and 2088, capsules cycled to 40,000 cycles under typical field operating conditions, shows little difference in overall deformation appearance.

The nonwelded and welded ends of the tested capsules are shown in photographs 6 and 7 respectively.

2. Bubble Tests

There were no observed bubble test failures at any of the cycling interval tests using the vacuum bubble test. All capsules passed the hot water bubble test after cycling.

3. Dimensional Measurements

The dimensional changes in the capsule were often very slight with generally the diameter of the capsule increasing only slightly. The largest increase in diamter was for capsule serial number 2079, cycled without a rubber cushion in the headhose; the diameter increased by 0.04mm.

The length of the capsules changed more than the diameter. Some became slightly shorter while others became longer. The greatest decrease, 0.36mm, was for capsule serial number 2088 cycled in the normal orientation and at typical field conditions for 40,000 cycles. The largest increase, 2.12mm, was for capsule serial number 2079 cycled for 40,000 cycles in normal orientation and at typical field conditions with the headhose cushion removed.

4. Weights

All capsules lost weight. The amount lost was very small and was closely related to the number of cycles the capsules were subjected to. Capsule serial number 2081, cycled 160,200 times, lost the most weight, 0.025 g.

5. Dye Penetrant Tests Unsectioned and Sectioned Cycled Capsules

There were no recognizably positive tests for dye penetrant for any of the cycled unsectioned capsules.

All the cycled capsules were sectioned equitorially and the inner capsule was examined by dye penetrant. The inside contents of capsule serial number 2077, cycled in the reverse orientation gave a very positive dye penetrant test from the dye penetrant applied before sectioning at the equator. A closer examination of the weld end of the sectioned capsule showed very positive evidence that the crack penetrated through the cap of the inner capsule.

None of the other capsules showed any evidence for a positive dye penetrant test at either the pre or post sectioning stages or at the sectioned stage when the two halves were treated with dye penetrant.

6. Inner Capsule

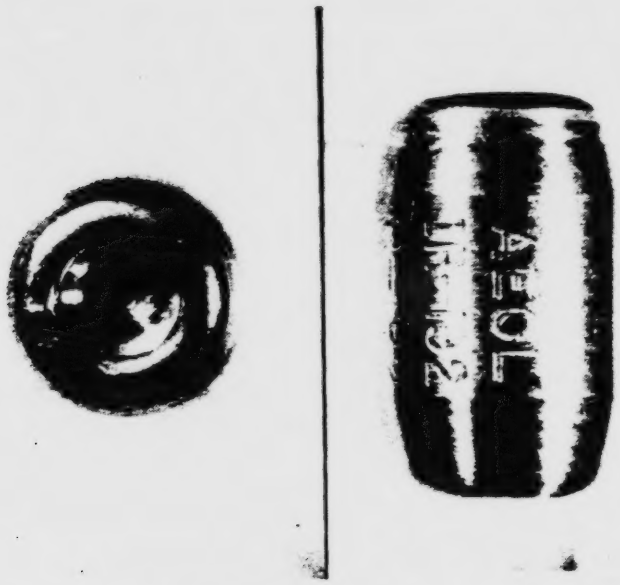
The inner capsules were highly deformed in several instances.

The inner capsules, after sectioning the body at the equator, are shown in photographs 8 and 9.

D. OBSERVATIONS

The observations for each cycling trial are presented in sequence as they are stated in the work statement.

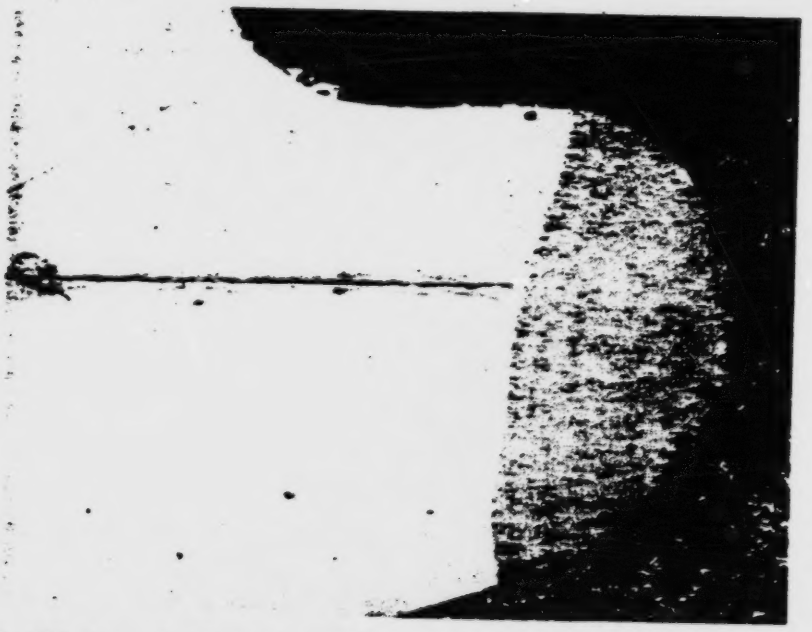
1. Capsule 2090



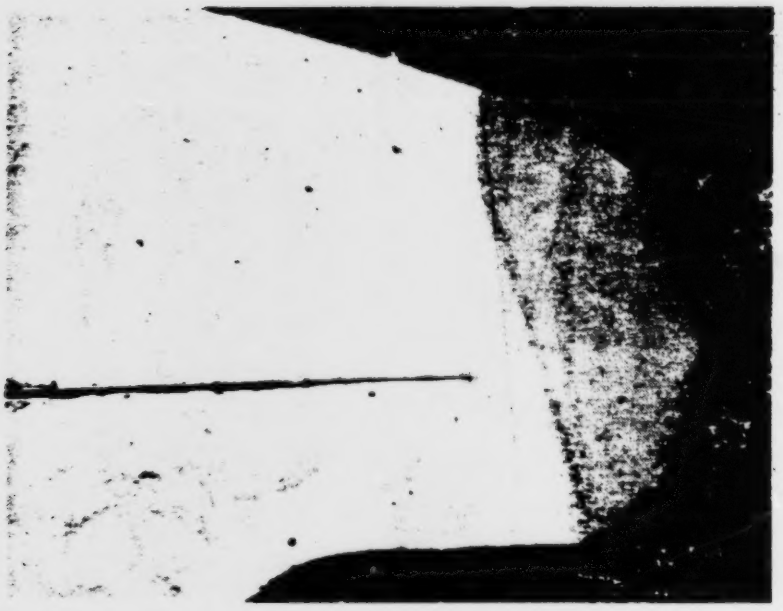
C-182 Capsule Serial Number 2090. As received. Photomacrograph showing weld end and side view 4.7X

2. Capsule 2085

C-182 Capsule Serial Number 2085. As received.
Capsule to be metallurgically examined.
Photomacrograph showing weld end and side view.
4.7X

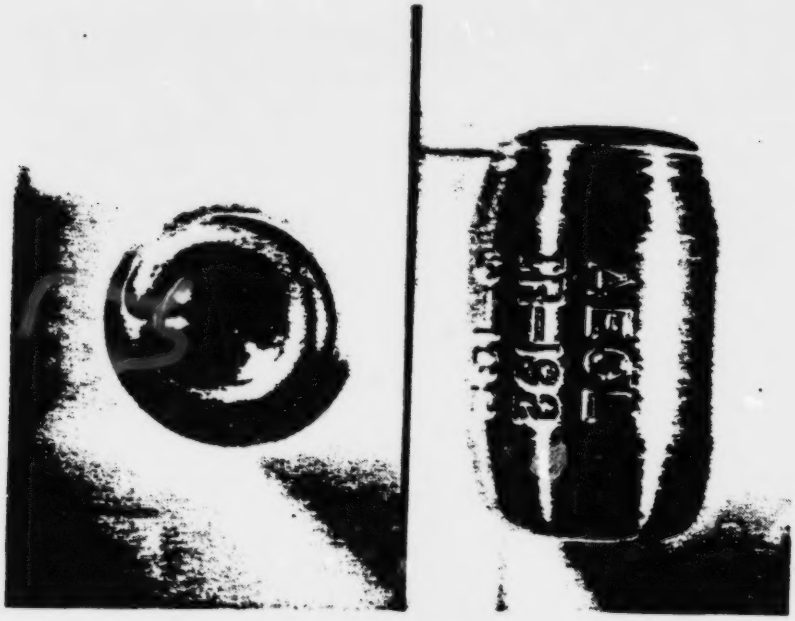


C-182 Capsule Serial Number 2085. As received.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

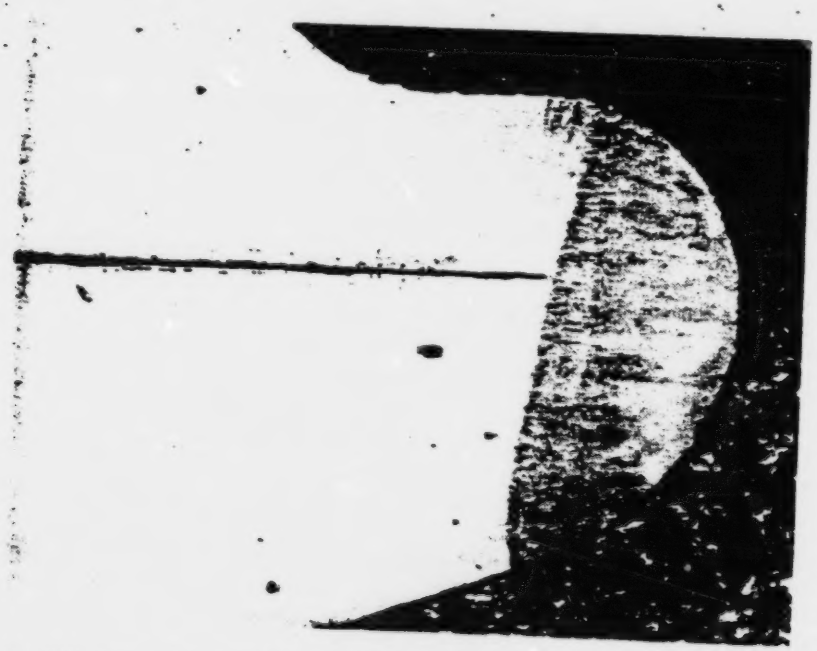


C-182 Capsule Serial Number 2085. As received.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

3. Capsule 2078



C-182 Capsule Serial Number 2078. As received.
Capsule to be metallurgically examined.
Photomacrograph showing weld end and side view.
4.7X



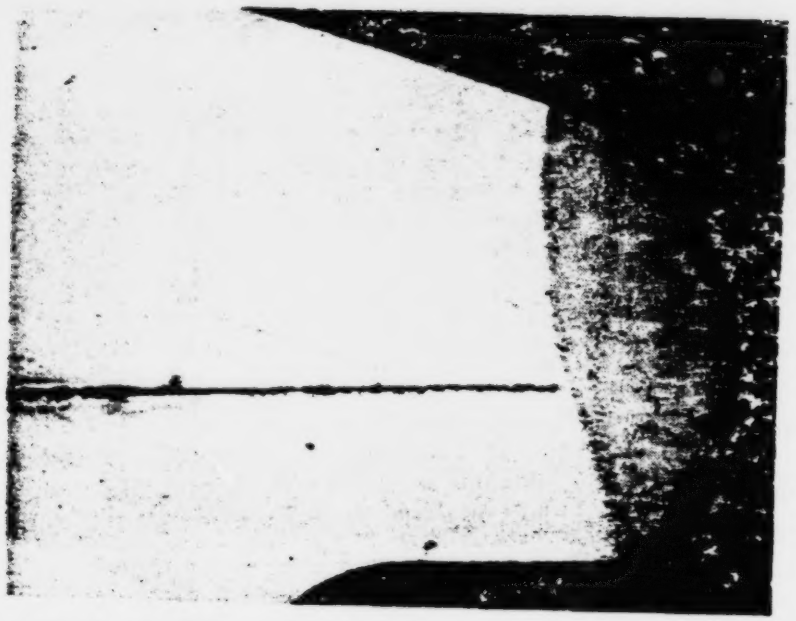
C-182 Capsule Serial Number 2078. As received.
Photomicrograph showing right cross-section of capsule of weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2078. As received.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

4. Capsule 2091

C-182 Capsule Serial Number 2091. As received.
Capsule to be metallurgically examined.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2091. As received.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2091. As received. Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

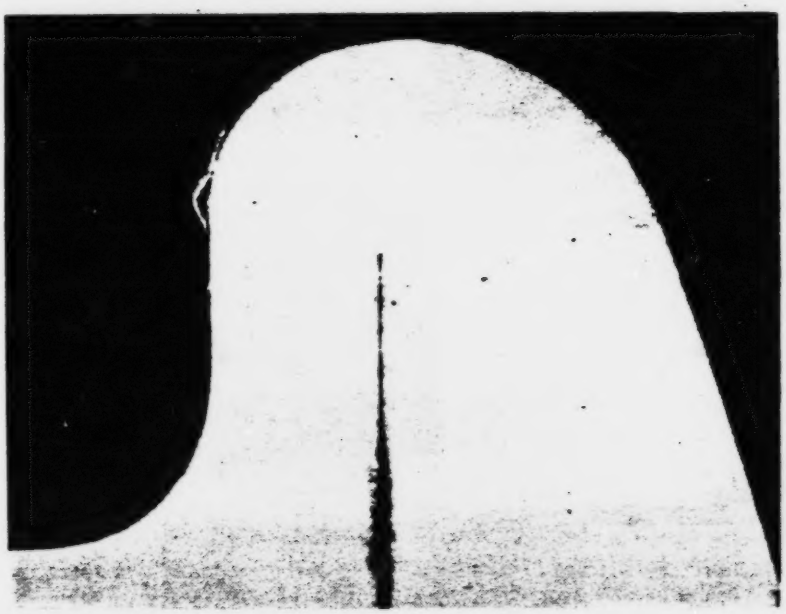
5. Capsule 2094

Capsule was not cycled. After machining the body at the equator, the contents were easily removed from the two halves of the body. Since this capsule was not tested it will be used as the reference.
Inner Capsule Diameter = 4.475mm (Bottom) 4.470 (Top)
Inner Capsule Length = 8.083mm
Spacer = 2.565mm Long 3.155 mm

DYE PENETRANT EXAMINATION

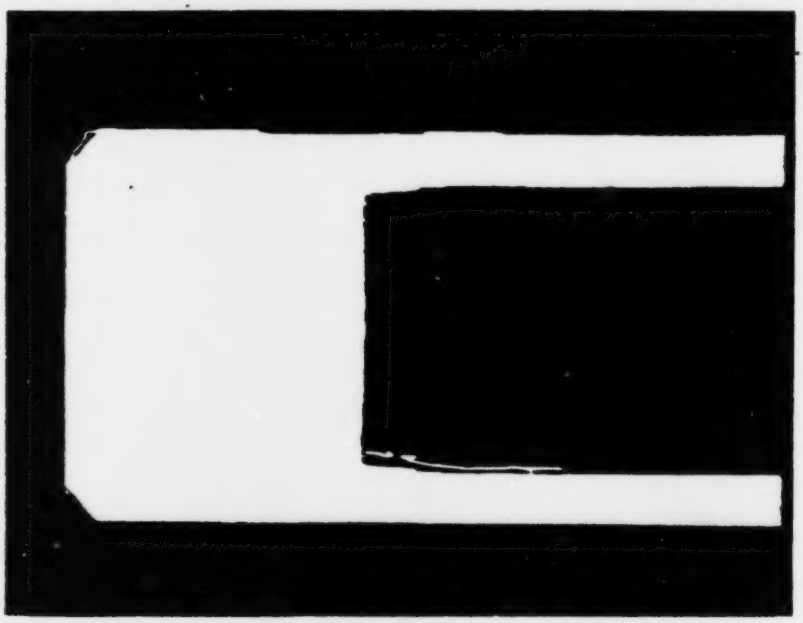
The outside surfaces of the insert were examined for defects using a fluorescent dye penetrant. The outside surfaces of the insert were later examined under UV light, however no visible defects were present. The upper half (welded end) of the body was also leak tested by filling the inside cavity with dye penetrant. The outside surfaces of the body were examined under UV light, however no dye penetrant was visible on the outside of the body.

C-182 Capsule Serial Number 2094. As received.
Capsule to be metallurgically examined.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2094. As received.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2094. As received.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2094. As received.
Photomicrograph showing cross section of insert.
12.5X

6. Capsule 2074

Tested to 40,000 cycles in Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.250	8.69	13.49	pass
May 28	250		8.69	13.44	pass
June 17	500	5.249	8.69	13.44	pass
June 18	1,000	5.248	8.69	13.45	pass
June 19	2,000	5.249	8.69	13.45	pass
June 24	5,000	5.246	8.69	13.46	pass
June 28	10,000	5.245	8.69	13.23	pass
July 5	20,000	5.245	8.70	13.27	pass
July 15	40,000	5.245	8.70	13.29	pass

Notes:

250 cycles - wearing around outside circumference of weld
500 cycles - wearing on sides and weld end
1,000 to 2,000 cycles - weld end beginning to round slightly
5,000 cycles - weld end mushrooming over sides of capsule
10,000 cycles - hammering on weld end on inside circumference due to plug wedged in camera
40,000 cycles - very noticeable mushroom effect on the weld end of the capsule

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: One indication 2mm long on welded end of capsule below deformation zone at metal fold. Remainder of capsule satisfactory.

SECTIONING CAPSULE AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

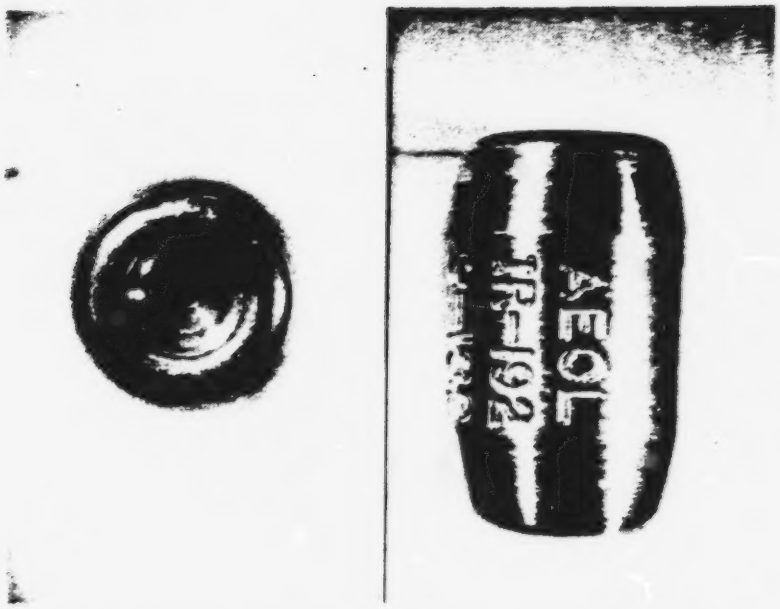
After the body of the capsule was sectioned at the equator, the body was separated into two parts with the insert remaining in the top half (welded end) of the body and removed from the bottom half (unwelded end) of the body. The insert was not able to be removed from the top half of the body with fingers. The bottom face and exposed walls of the insert showed a dimpled appearance. The corresponding interior surfaces of the bottom half of the body also showed this dimpled appearance. Under UV examination, no fluorescence was noted on the outside surfaces of the insert or the interior of the bottom half of the body.
Insert was removed from the top half (welded end) of the body. The contents of the insert (spacer & shims) could not be removed. The dimensions of the insert are 4.54mm in diameter at top and 8.04mm in length.

DYE PENETRANT EXAMINATION - INSERT

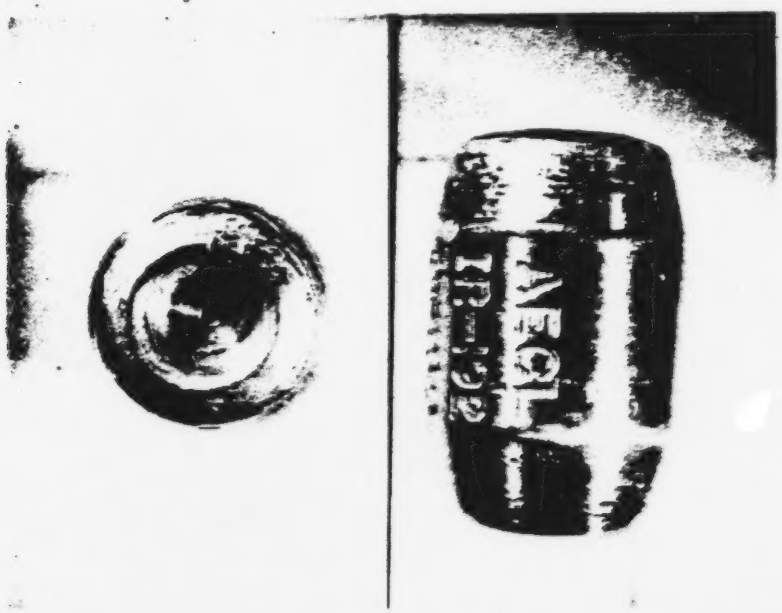
The outside surfaces of the insert were examined for defects using fluorescent dye penetrant. The capsule was examined using UV light, no visible defects were detected.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

The upper half (welded-end) of the body was also inspected for leaks by filling the inside cavity with dye penetrant. The body was examined later using UV light, no leakage of dye penetrant from the inside to the outside of the capsule was detected.

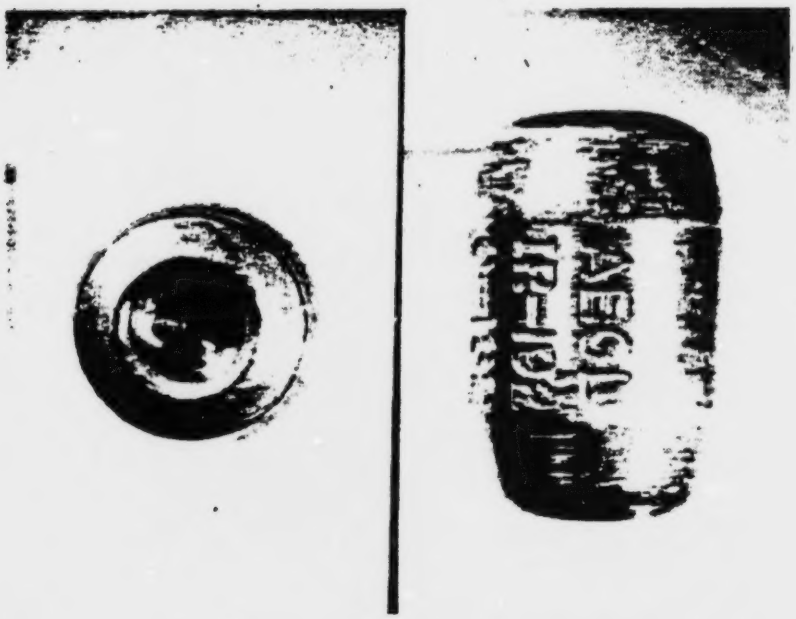


C-182 Capsule Serial Number 2074. As received.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

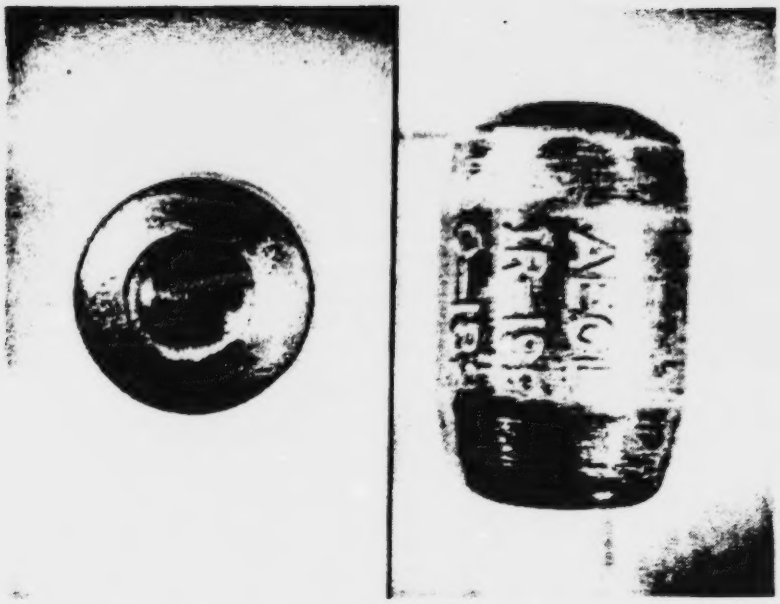


C-182 Capsule Serial Number 2074. 250 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2074. 500 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

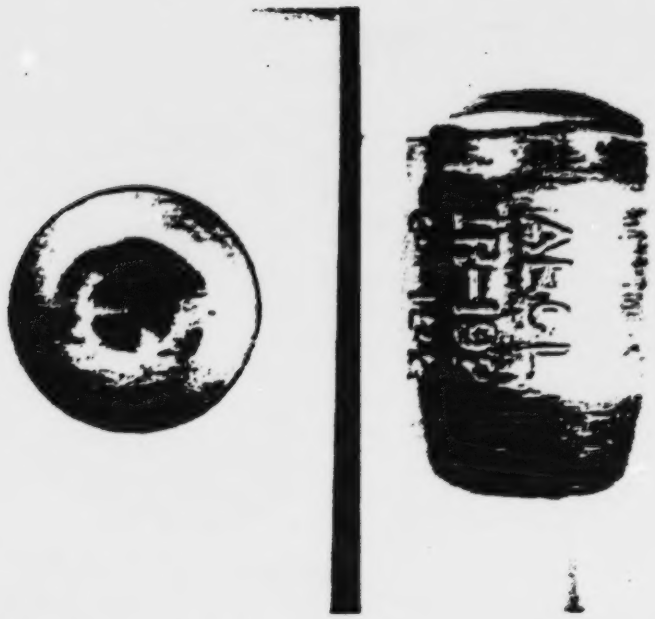


C-182 Capsule Serial Number 2074. 1,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

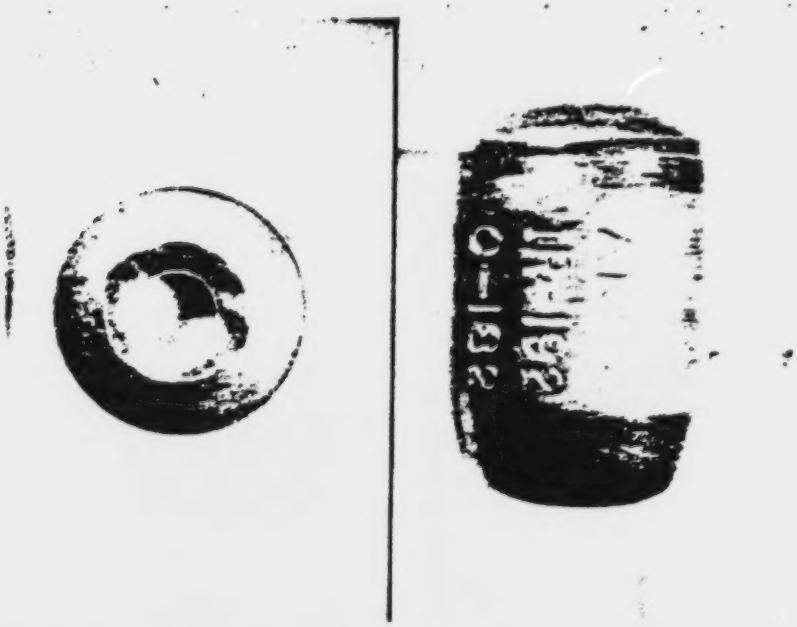


C-182 Capsule Number 2074. 2,000 Cycles.
Normal orientation and typical operating conditions.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2074. 5,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

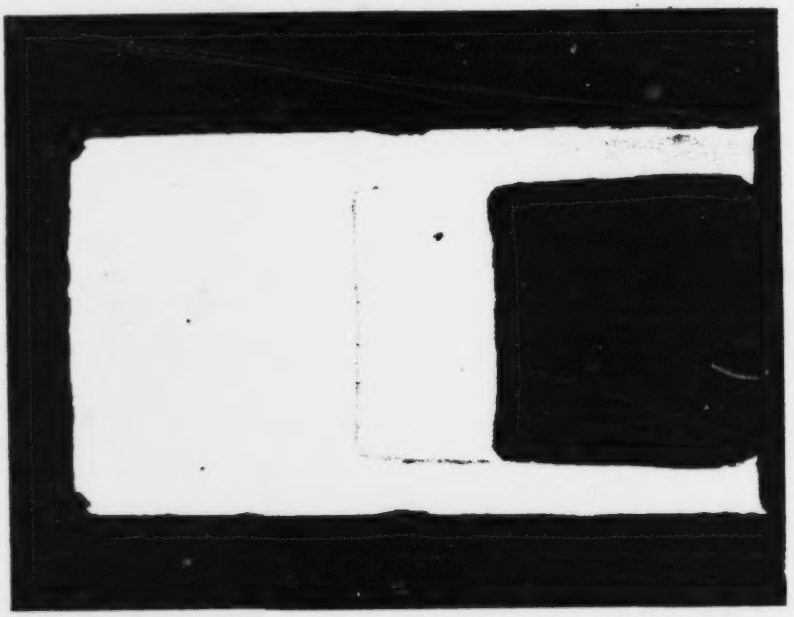


C-182 Capsule Serial Number 2074. 10,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2074. 20,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2074. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2074. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2074. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2074. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

7. Capsule 2076

Tested to 40,000 cycles in Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.233	8.70	13.38	pass
May 30	250		8.70	13.36	pass
June 17	500	5.232	8.71	13.35	pass
June 19	1,000	5.233	8.71	13.33	pass
June 19	2,000	5.231	8.70	13.35	pass
July 2	5,000	5.231	8.71	12.97	pass
July 10	10,000	5.230	8.71	13.00	pass
July 17	20,000	5.230	8.71	13.02	pass
July 26	40,000	5.230	8.71	13.06	pass

Notes:

250 cycles - wearing around outside edge of weld end
- no noticeable marking on bottom end
1000 cycles - some wearing (small nicks) around circumference
5000 cycles - flattening on inside circumference of weld due to metal plug stuck in camera

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: One small indication below deformation zone on welded end of capsule. Remainder of capsule satisfactory.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule remained intact. The capsules were examined and the following noted:

After sectioning the body at the equator, the body separated into two parts. The insert was removed from the bottom half of the body and remained intact with the top half (welded end) of the body. The insert was not able to be removed from the welded end (top end) of the capsule with fingers. The outside walls and bottom face of the insert contained a dimpled appearance. The corresponding surface of the bottom half of the body also showed a dimpled appearance. The diameter of the bottom of the insert was 4.495mm.
The insert and inside surfaces of the bottom half of the body were inspected using a UV light. No fluorescence was noted.
The insert was removed from the top half (welded end) of the body by holding the insert in a collet and pulling off the body. The contents of the insert could not be removed from the insert itself. The spacer recess distance was 0.70mm.

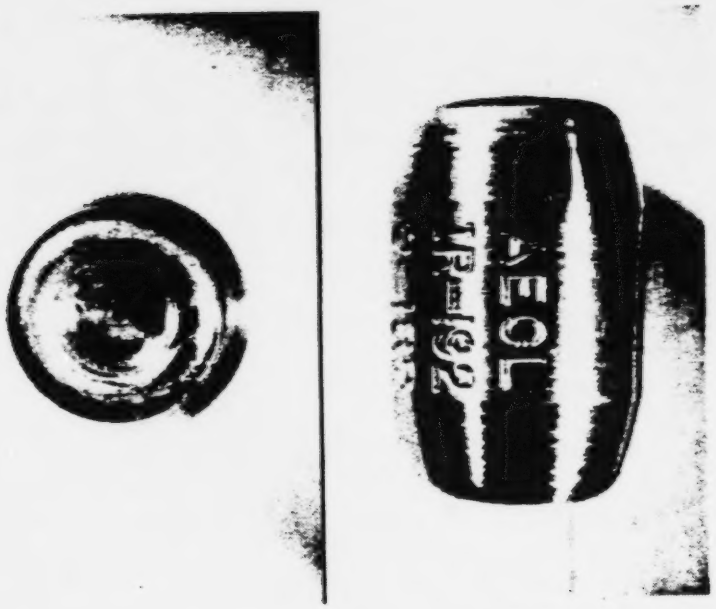
The length of the insert was 8.0655mm and its diameter at top was 4.565mm.

DYE PENETRANT EXAMINATION - INSERT

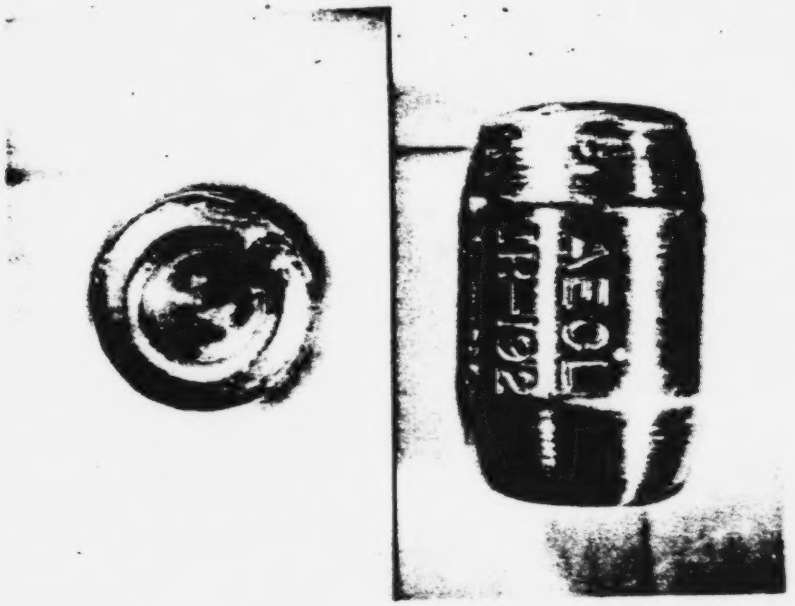
The outside surfaces of the insert were examined for defects using fluorescent dye penetrant. After soaking, the capsule was examined under UV light and no defects were noticed.

DYE PENETRANT EXAMINATION - WELDED END OF CAPSULE

The upper half (welded end) of the body was tested by filling the inner cavity with dye penetrant. After allowing to soak for several hours, no dye penetrant was observed on the outside surfaces of the body.

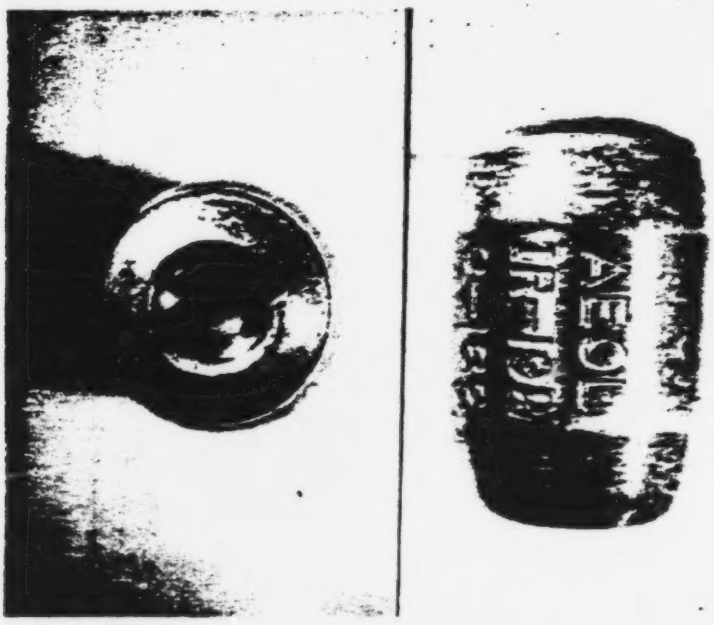


C-182 Capsule Serial Number 2076. As received.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

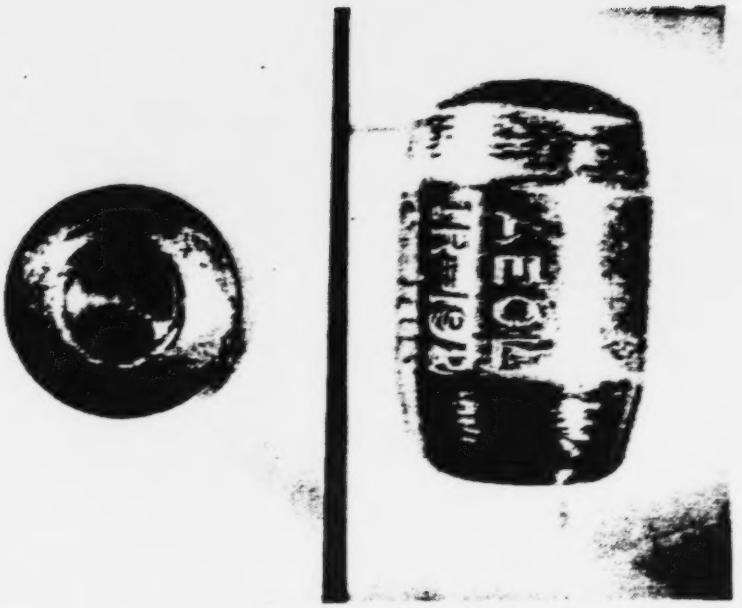


C-182 Capsule Serial Number 2076. 250 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

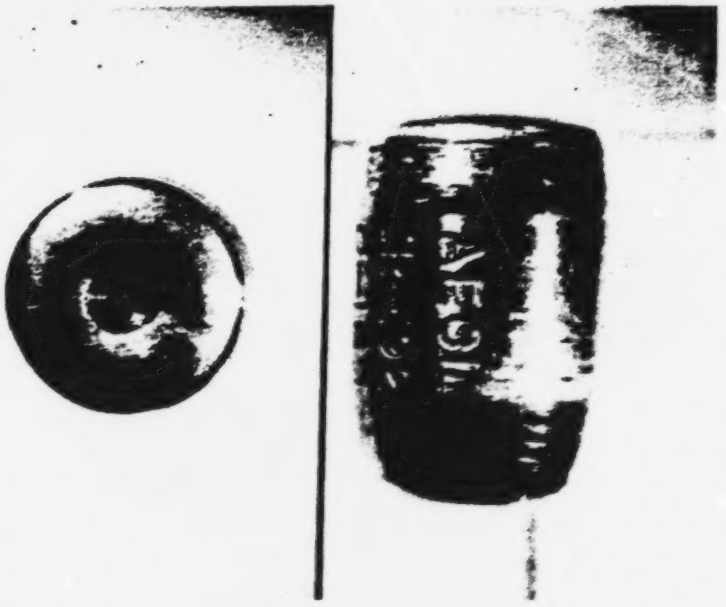
C-182 Capsule Serial Number 2076. 500 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2076. 1,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

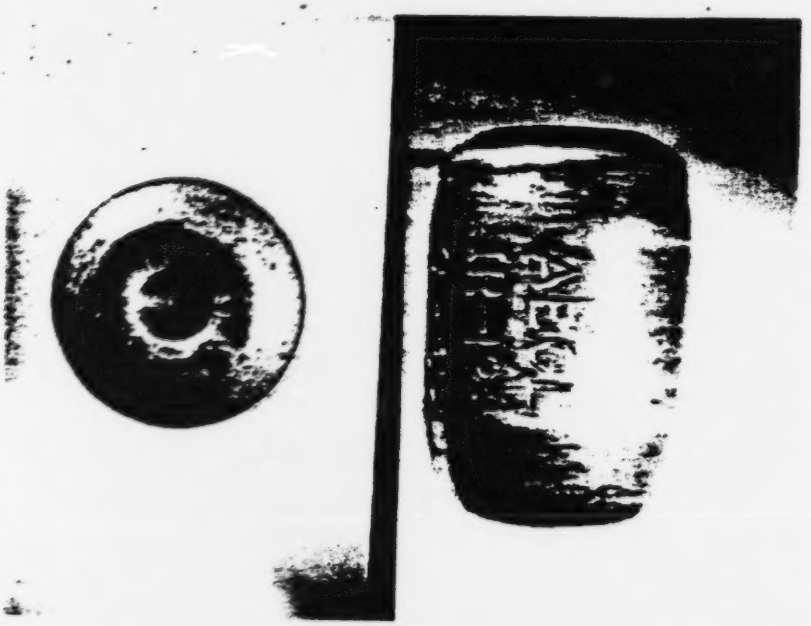


C-182 Capsule Serial Number 2076. 2,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

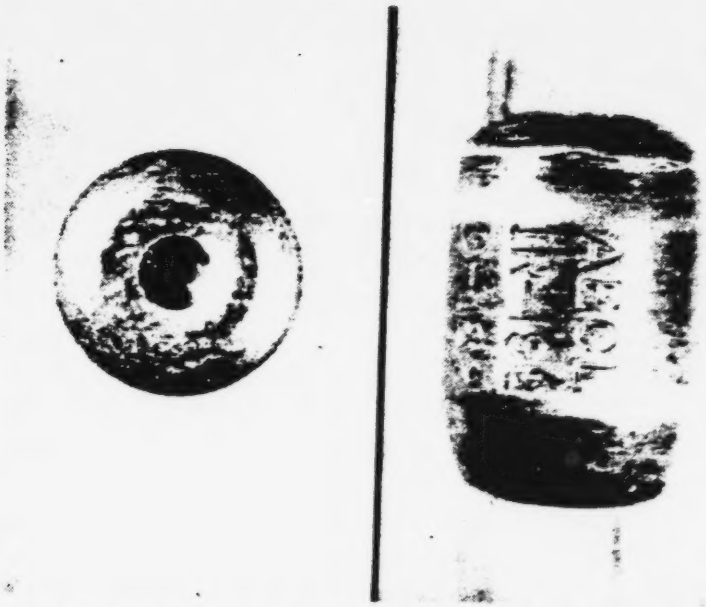


C-182 Capsule Serial Number 2076. 5,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

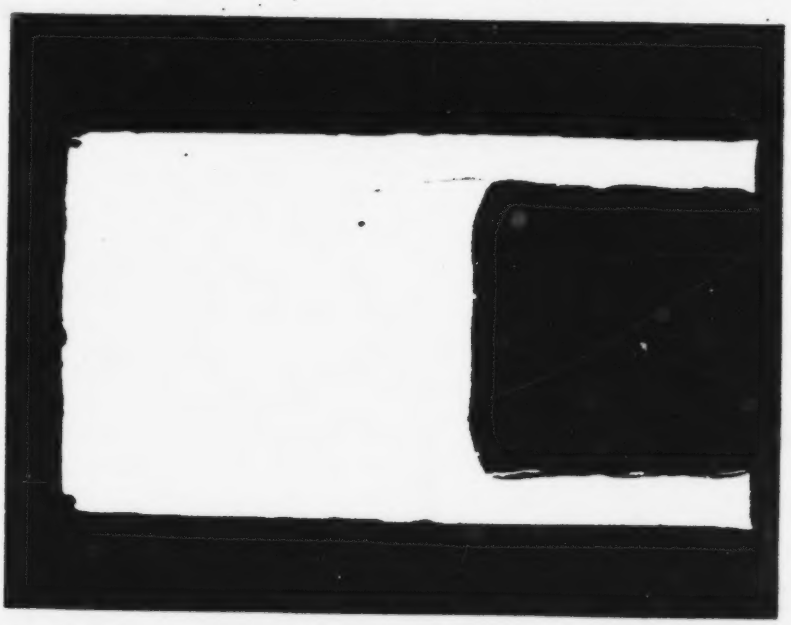
C-182 Capsule Serial Number 2076. 10,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2076. 20,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

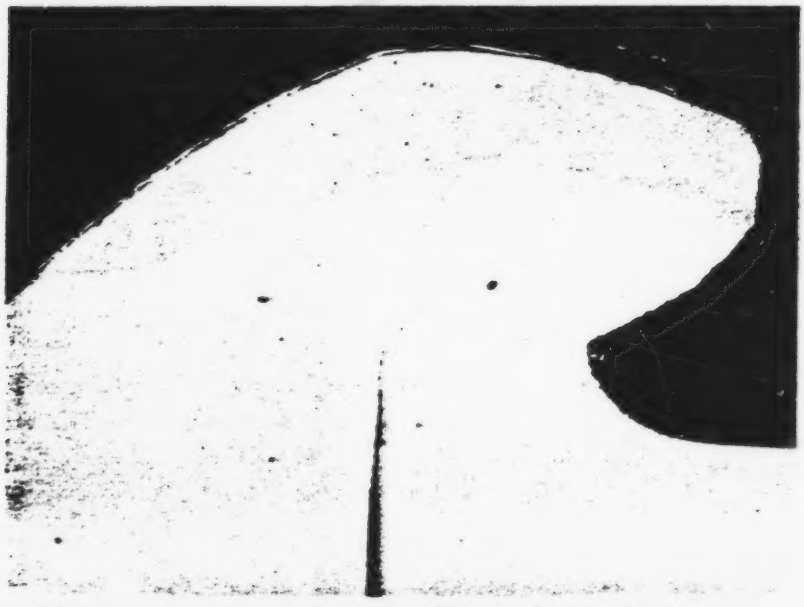


C-182 Capsule Serial Number 2076. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2076. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2076. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2076. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

8. Capsule 2088

Tested to 40,000 cycles in Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.234	8.70	13.40	pass
May 29	250		8.71	13.35	pass
June 17	500	5.234	8.70	13.34	pass
June 18	1,000	5.232	8.71	13.33	pass
June 19	2,000	5.231	8.71	13.34	pass
July 2	10,000	5.230	8.72	13.06	pass
July 4	20,000	5.229	8.72	13.07	pass
July 10	40,000	5.228	8.72	13.04	pass

Notes:

250 cycles - wearing around outside edge of weld end only
1000 cycles - knicks around bottom circumference (worn out grommet)
10,000 cycles - inside circumference flattened slightly

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: Two indications 2mm long on weld end of capsule below deformation zone at metal fold. Remainder of capsule satisfactory.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

After sectioning the outer capsule at the equator, the inner capsule was removed from the top (welded) end of the capsule and remained intact with the bottom (unwelded) of the outer capsule. A dimpled appearance was noted on the end and walls of the inner capsule. A corresponding appearance was noted on the inside walls and end cap of the body. When the insert was held in the vertical position, the spacer rested in a position 0.7mm lower than the top of the insert.
The diameter of the insert = 4.525mm (Top)
Under UV inspection, no fluorescence was detected on the inside surfaces of the capsule.
The insert was removed from the bottom of the body by holding the insert in a collet and removing the body. The contents of the insert could not be removed. The dimensions of the insert were 8.01mm in height and 4.51mm in diameter at the bottom.

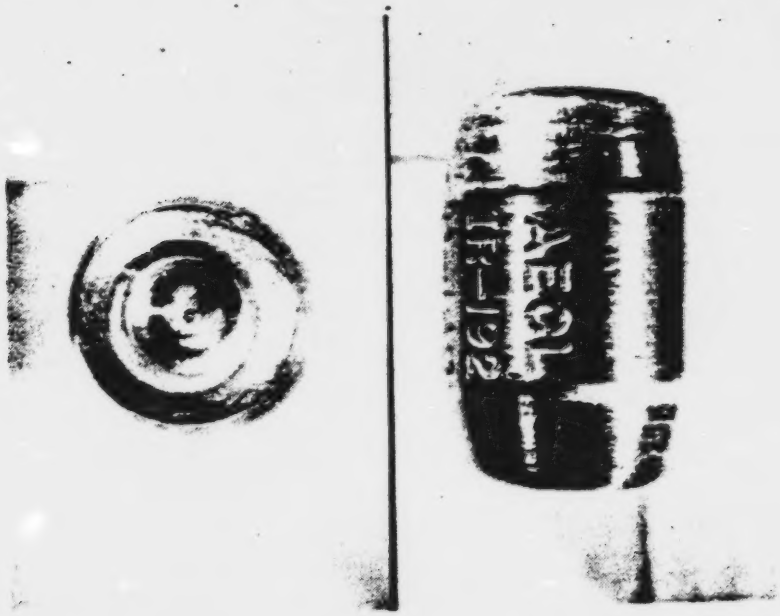
DYE PENETRANT EXAMINATION - INSERT

The outside surfaces of the insert were inspected for flaws using a fluorescent dye pentrant. Under UV examination, no indications were detected.

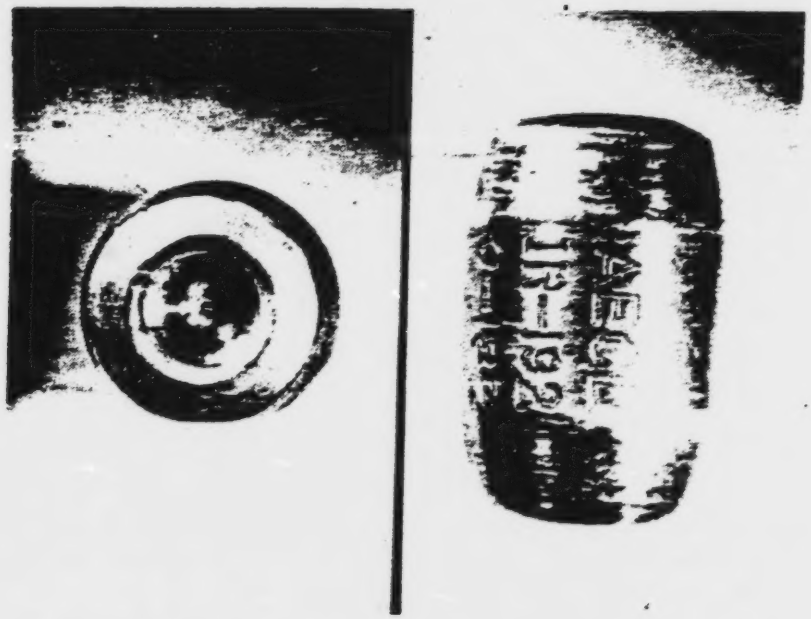
DYE PENETRANT EXAMINATION - WELDED END OF CAPSULE

The inside cavity of the welded end of the capsule was filled with dye penetrant to determine if defects were present which would allow dye penetrant to penetrate to the outside of the capsule. Under UV examination, it was observed that no dye penetrant was visible on the outside of the capsule.

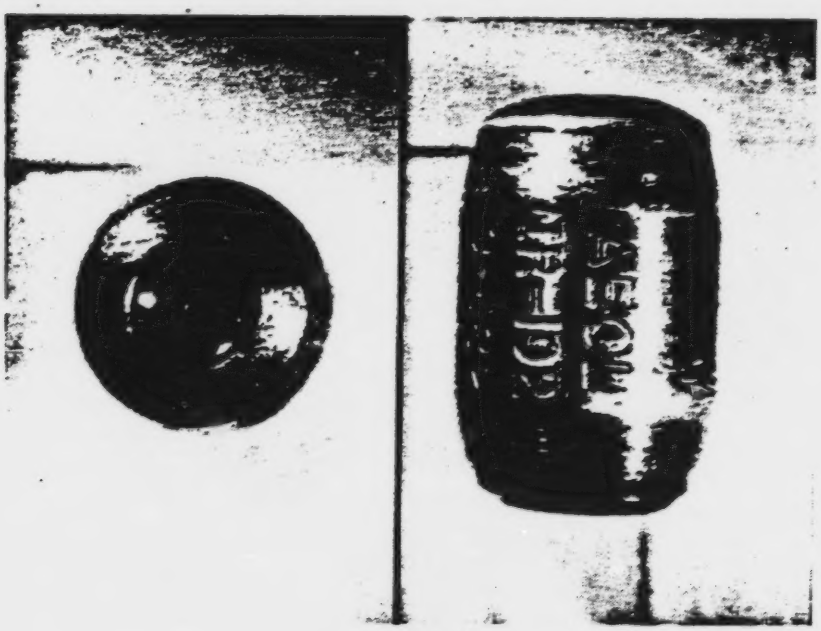
C-182 Capsule Serial Number 2088. As received.
Normal orientation and typical field operating conditions.
Photomacroraph showing weld end and side view.
4.7X



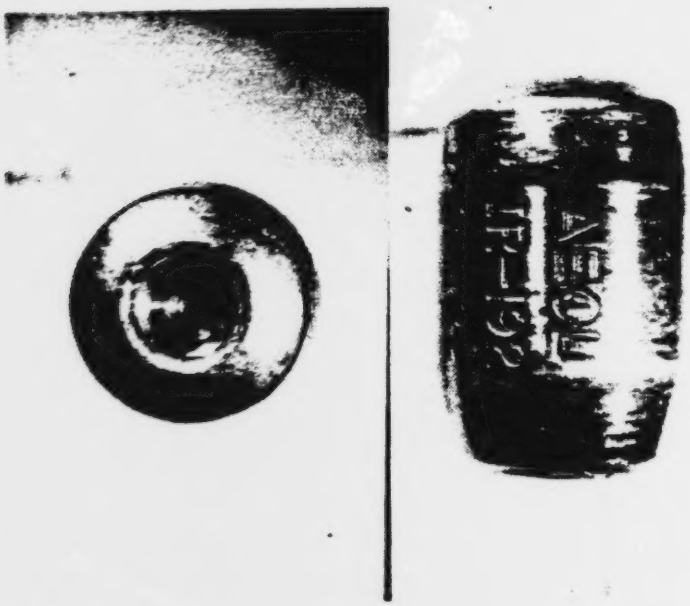
C-182 Capsule Serial Number 2088. 250 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



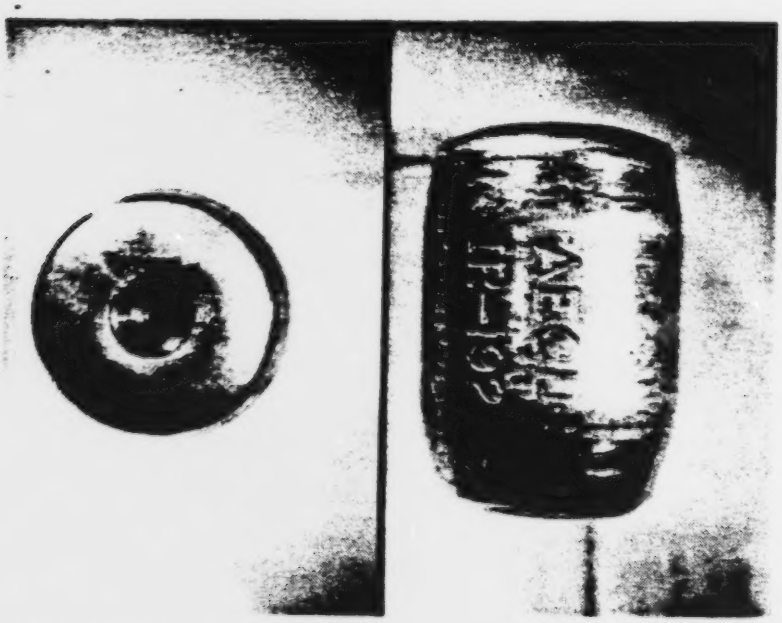
C-182 Capsule Serial Number 2088. 500 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2088. 1,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

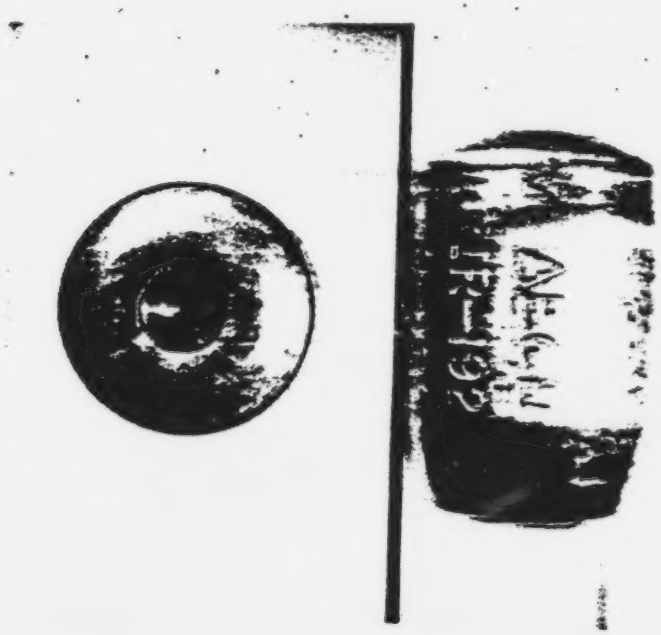


C-182 Capsule Serial Number 2088. 2,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



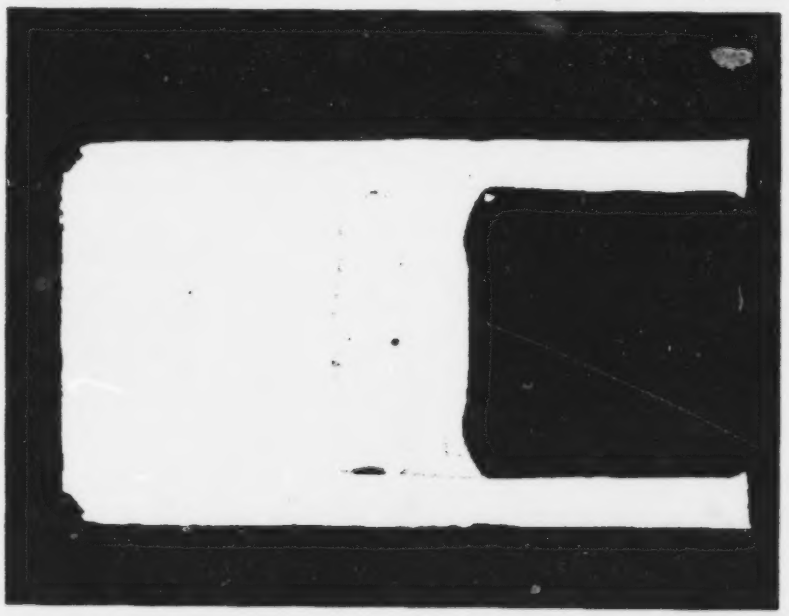
C-182 Capsule Serial Number 2088. 5,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2088. 10,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2088. 20,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2088. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2088. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2088. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2088. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

9. Capsule 2083

Tested to 40,000 cycles in Normal Orientation

Maximum Air Pressure & Vacuum

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.237	8.69	13.49	pass
Sept. 9	250	5.237	8.68	13.51	pass
Sept. 9	500	5.237	8.69	13.52	pass
Sept. 10	1,000	5.237	8.68	13.53	pass
Sept. 10	2,000	5.236	8.69	13.54	pass
Sept. 10	5,000	5.236	8.68	13.56	pass
Sept. 11	10,000	5.236	8.68	13.60	pass
Sept. 14	20,000	5.235	8.68	13.66	pass
Sept. 19	40,000	5.232	8.69	13.76	pass

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: No visible indications on outside of capsule.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations were noted:

After sectioning the body at the equator, the capsule separated with the insert remaining intact with the bottom of the body. The spacer was able to be removed from the insert. Upon examination it was noticed that no further ontents were present in the insert. It apears that the material which normally replaces the radioactive material has been mechanically attached to the spacer. The dimensions of the spacer are 2.60mm in height and 3.21mm in diameter. The spacer also rested in a position 0.80mm lower than the top of the insert.

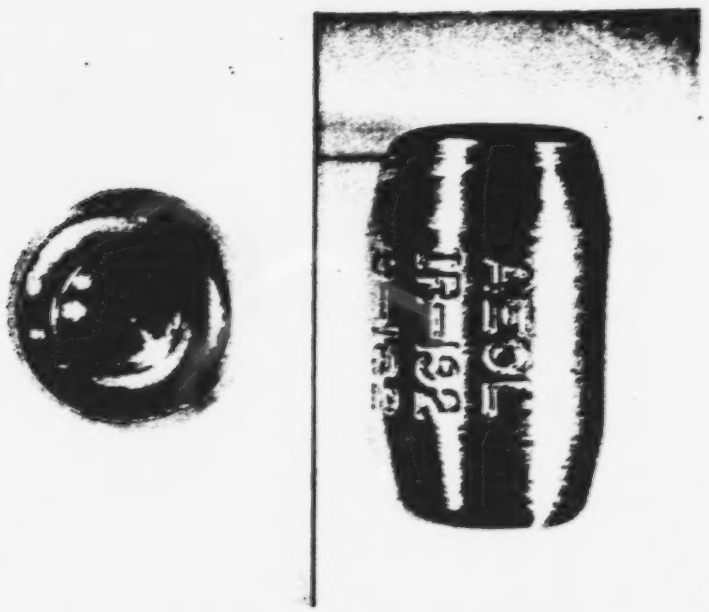
The outer walls of the insert and the face of the spacer show a dimpled appearance. The corresponding surfaces (inside walls of the welded end) of the body also show the same dimpled appearance. The insert and body was examined under UV light, however no evidence of fluorescence or dye penetrant entering the inside of the capsule was detected. The dimensions of the insert are 8.21mm in height and 4.55mm in diameter at the top and 4.48mm in diamter at the bottom.

DYE PENETRANT EXAMINATION - INSERT

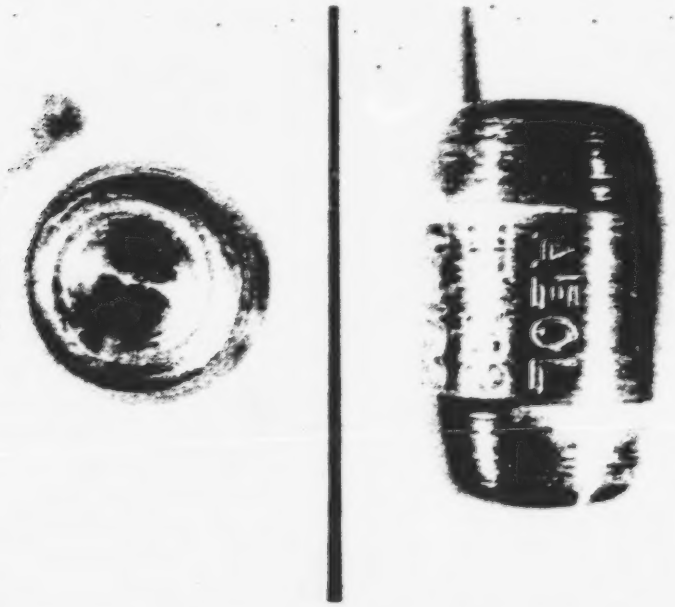
The outside surfaces of the insert were examined for defects using a fluorescent dye penetrant. Under UV examination, no visible efects were noticed on the outside of the insert.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

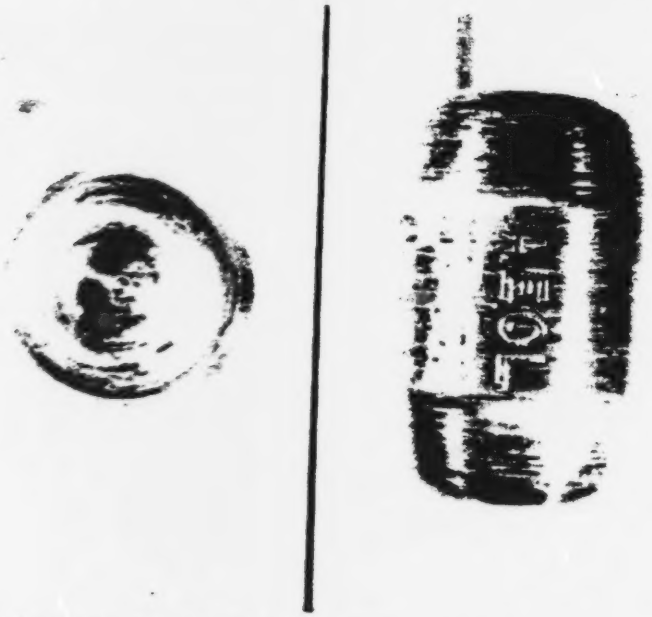
The top (welded end) of the body was leak tested by filling the inside cavity with dye penetrant and allowing to stand overnight. Under UV examination, it was determined that no dye penetrant was visible on the outer surfaces of the body.



C-182 Capsule Serial Number 2083. As received.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X

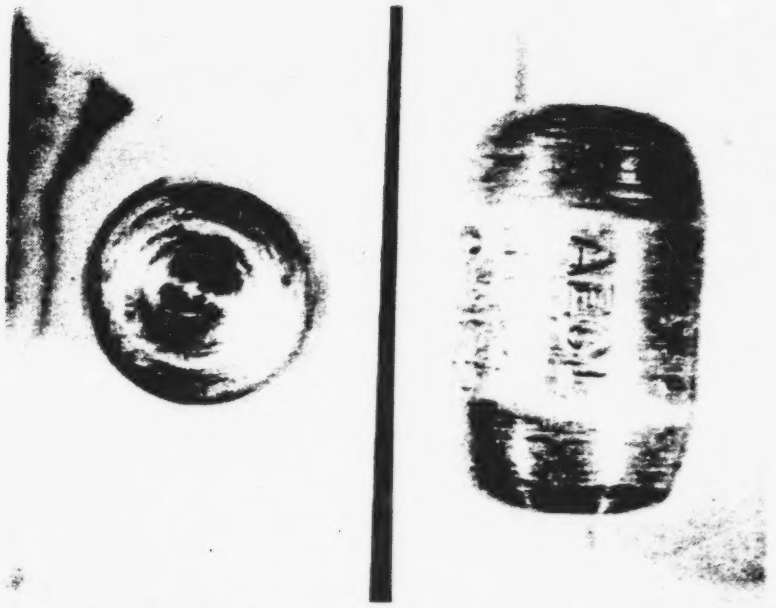


C-182 Capsule Serial Number 2083. 250 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X

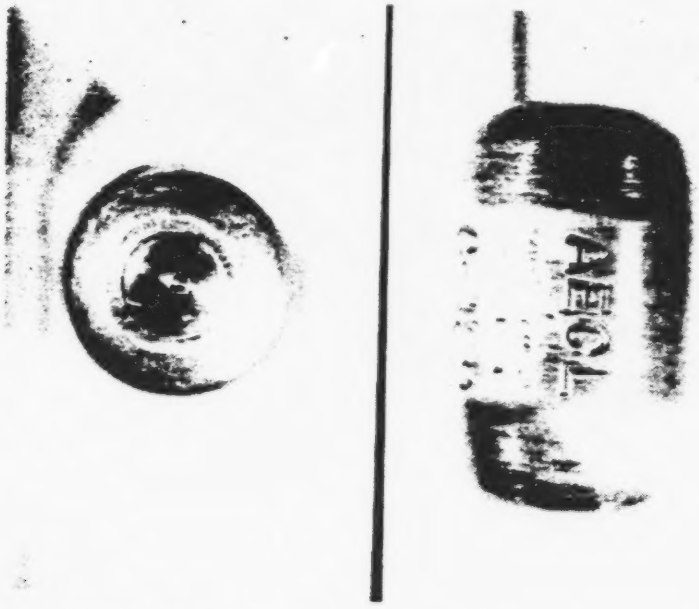


C-182 Capsule Serial Number 2083. 500 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X

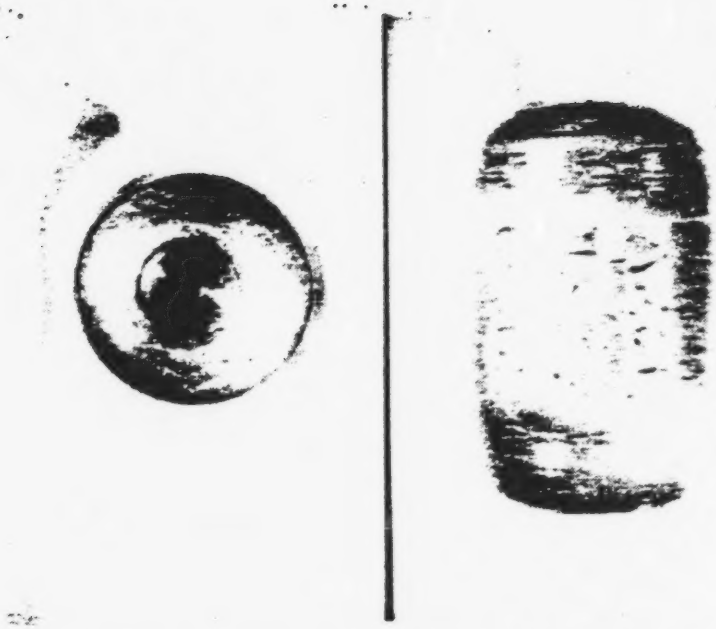
C-182 Capsule Serial Number 2083. 1,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2083. 2,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X

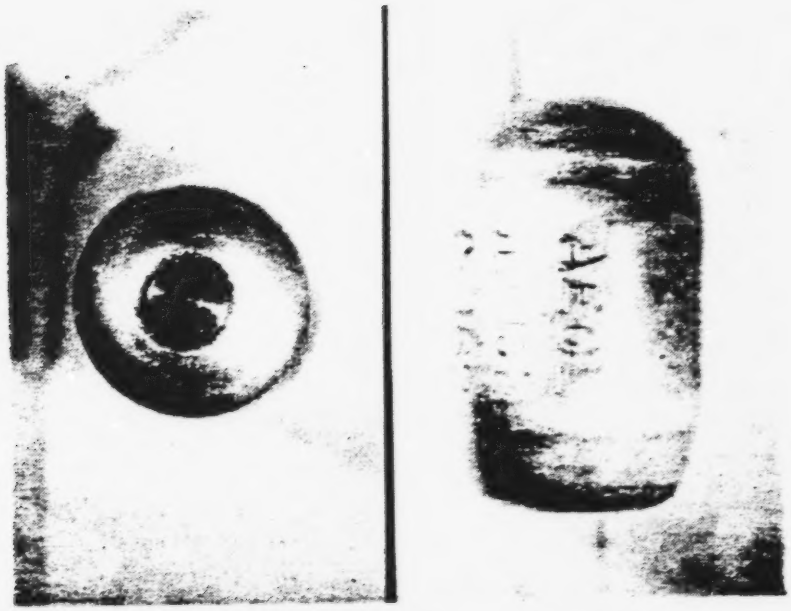


C-182 Capsule Serial Number 2083. 5,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X

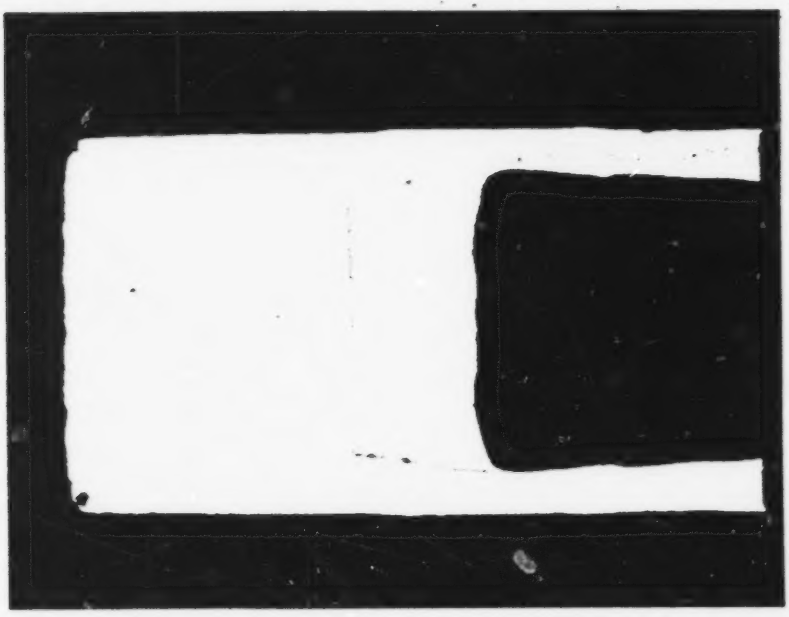


C-182 Capsule Serial Number 2083. 10,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2083. 20,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2083. 40,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2083. 40,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2083. 40,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2083. 40,000 Cycles.
Normal orientation with maximum air pressure and vacuum.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

10. Capsule 2077

Tested to 40,000 ih Reverse Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.242	8.70	13.40	pass
May 30	250		8.70	13.42	pass
June 18	500	5.245	8.70	13.42	pass
June 19	1,000	5.243			pass
June 24	2,000	5.243	8.71	13.48	pass
July 16	5,000	5.241	8.71	13.48	pass
July 19	10,000	5.240	8.71	13.55	pass
July 31	20,000	5.234	8.72	13.89	pass
Aug. 8	40,000	5.227	8.72	13.89	pass

Notes:
2000 cycles - little damage to weld end of capsule
- bottom end becoming rounded

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: No visible indications on outside of capsule.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

After sectioning the body at the equator, the capsule was separated. The insert was removed from the bottom of the body and remained in the top (welded end) of the body. The insert was covered with a thin layer of black material which is undefined at this time. The bottom and wall surfaces of the insert show a dimpled appearance. The corresponding surfaces of the body also have this dimpled appearance. A small amount of green-yellow material was noticed on the bottom of the insert. This material was examined under UV light and showed fluorescence. Fluorescence was also noticed on the outside walls of the insert. The material is likely dye penetrant and would of had to penetrate through a defect to reach the insert. Upon further examination of the weld, a circumferential crack was detected on the inside wall of the capsule cap.

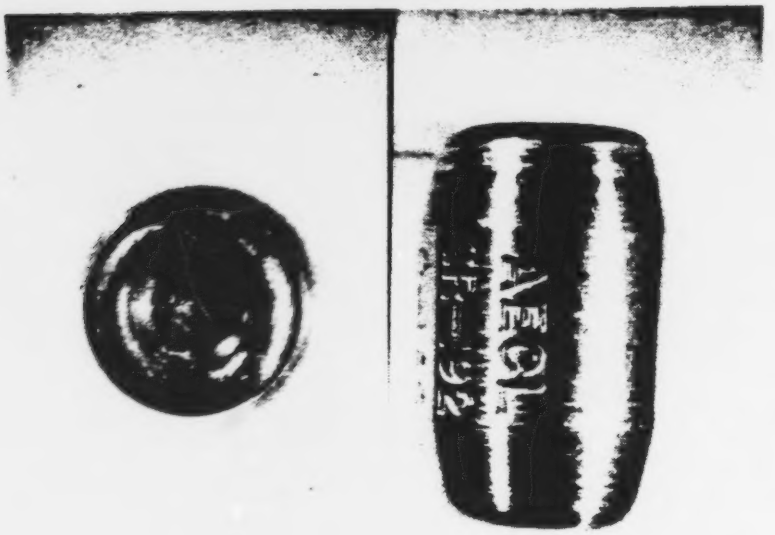
The insert was removed from the top half (welded end) of the body by holding the insert in a collet and pulling the body off the insert. The spacer was able to be removed from the insert. All of the internal surfaces of the capsule contained a black 'oily' coating and fluorescent dye penetrant. The shims, replacing normally radioactive material, could not be removed from the insert. The dimensions of the spacer are 2.70mm in height and 3.17mm in diameter. The dimensions of the insert are 4.57mm in diameter at the top and 8.01mm in height.

DYE PENETRANT EXAMINATION - INSERT

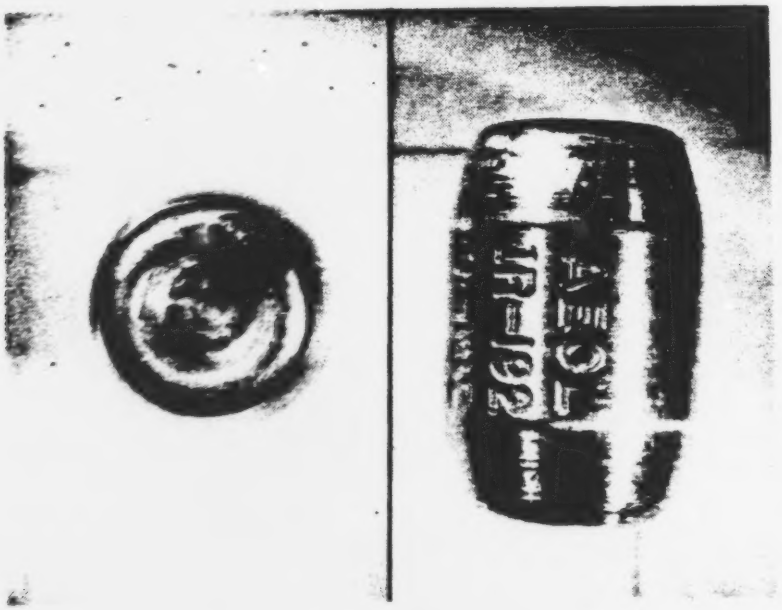
The outside surfaces of the insert of the capsule were inspected for defects using a fluorescent dye penetrant. The insert was examined under UV light, however no defects were visible.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

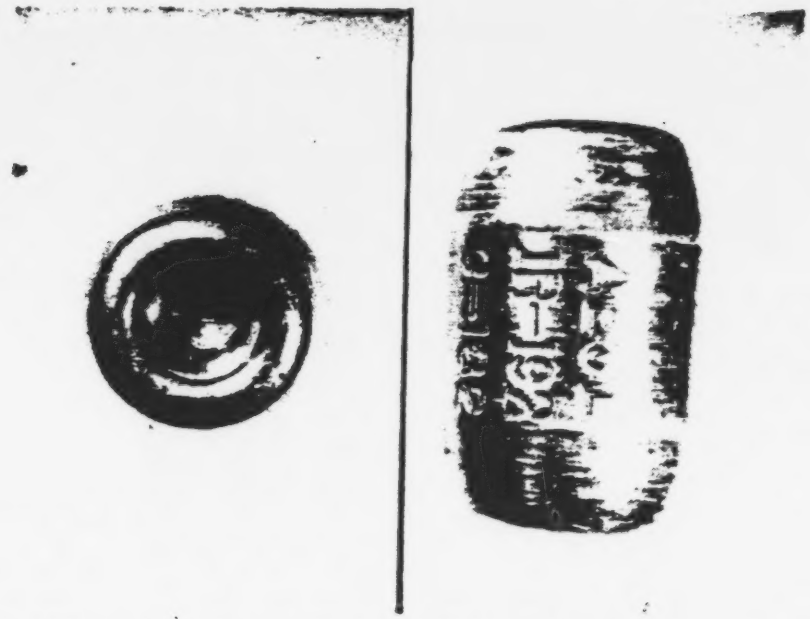
The upper half (welded end) of the body was tested for leakage by filling the inside cavity with dye penetrant. After soaking for only a few minutes, the capsule was observed under UV light. Very significant amounts of dye penetrant were detected on the area of the cap. This confirms that a leak path is present in the welded end of the capsule.



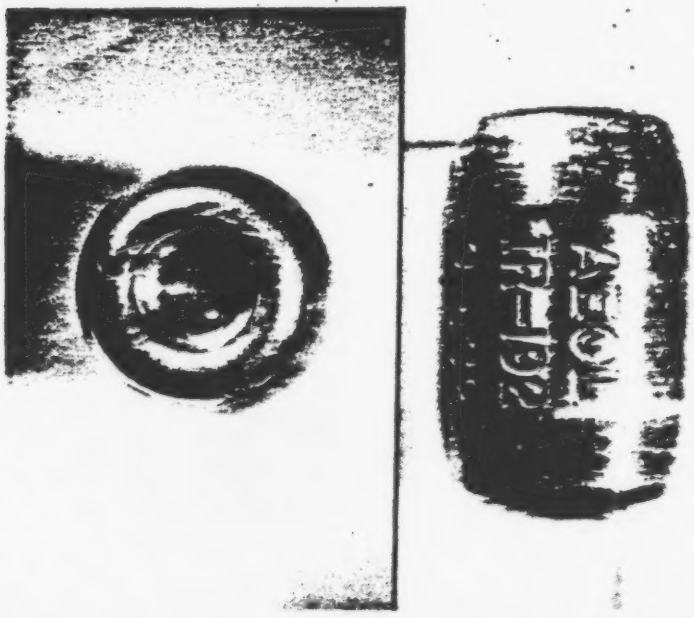
C-182 Capsule Serial Number 2077. As received.
Photomacrograph showing weld end and side view.
4.7X



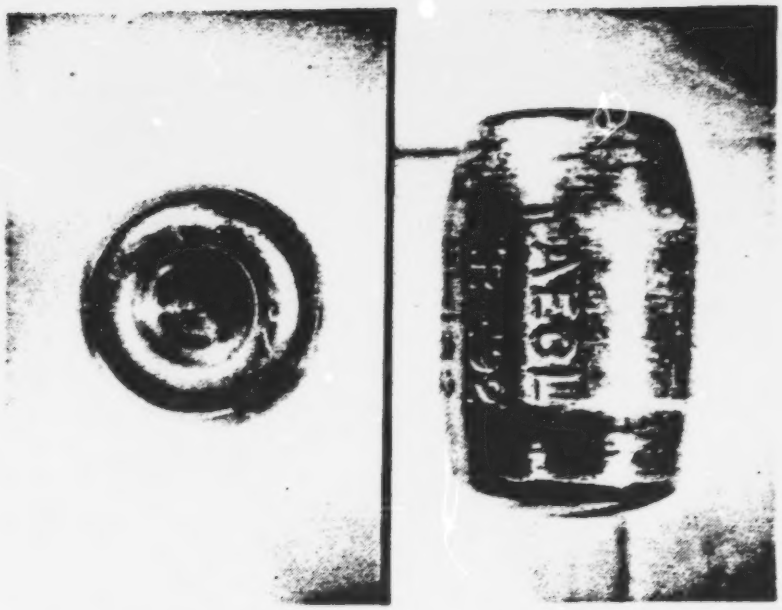
C-182 Capsule Serial Number 2077. 250 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



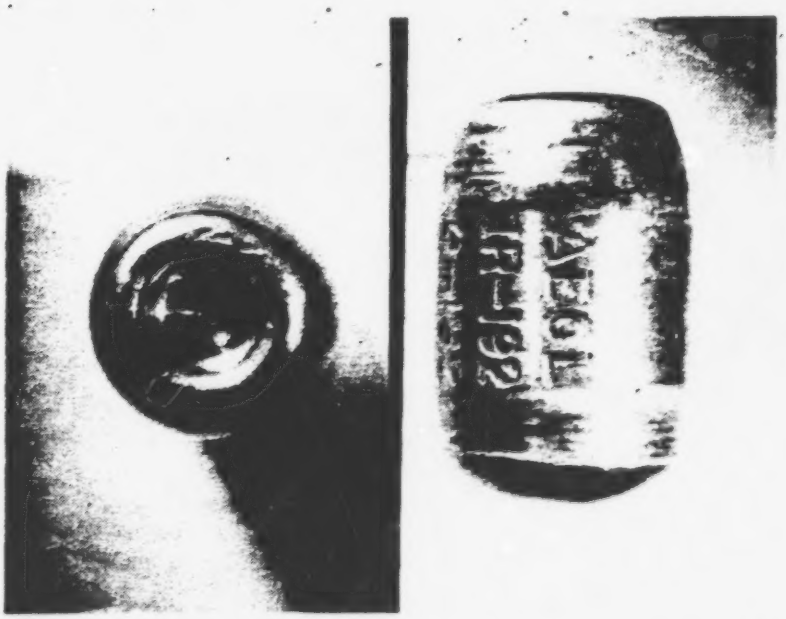
C-182 Capsule Serial Number 2077. 500 Cycles.
Reserve orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



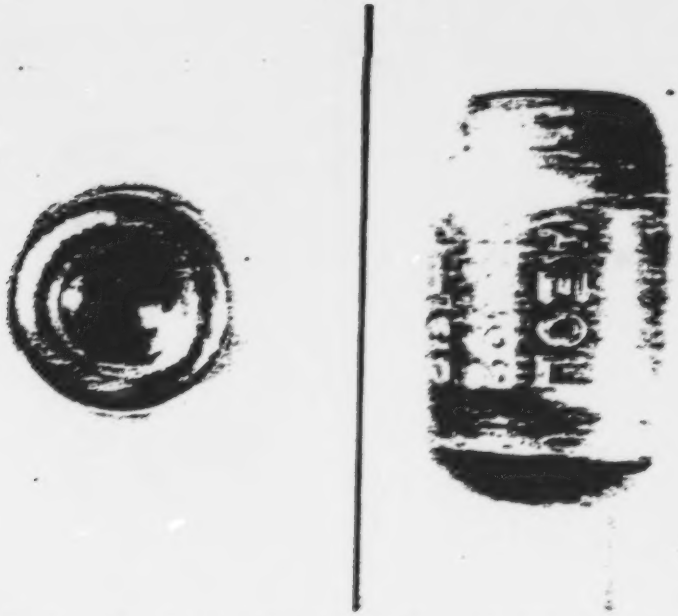
C-182 Capsule Serial Number 2077. 1,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



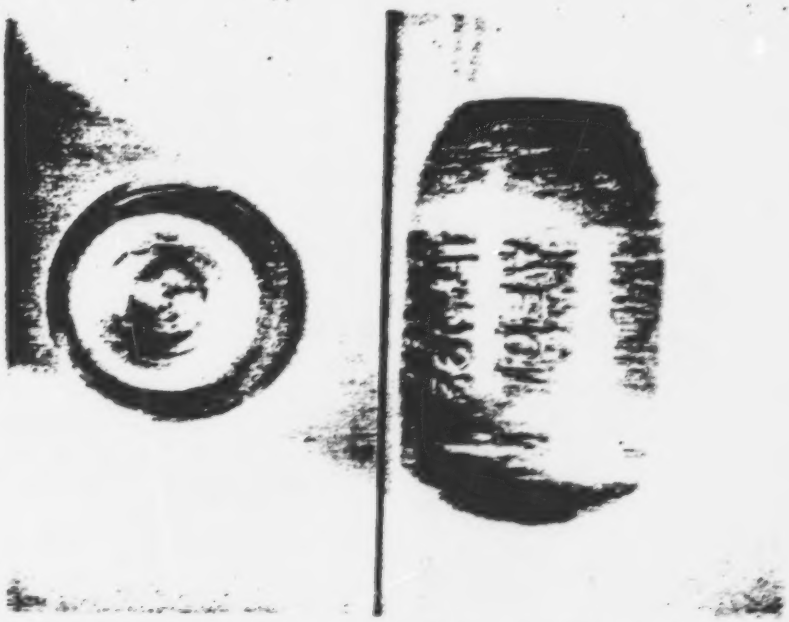
C-182 Capsule Serial Number 2077. 2,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



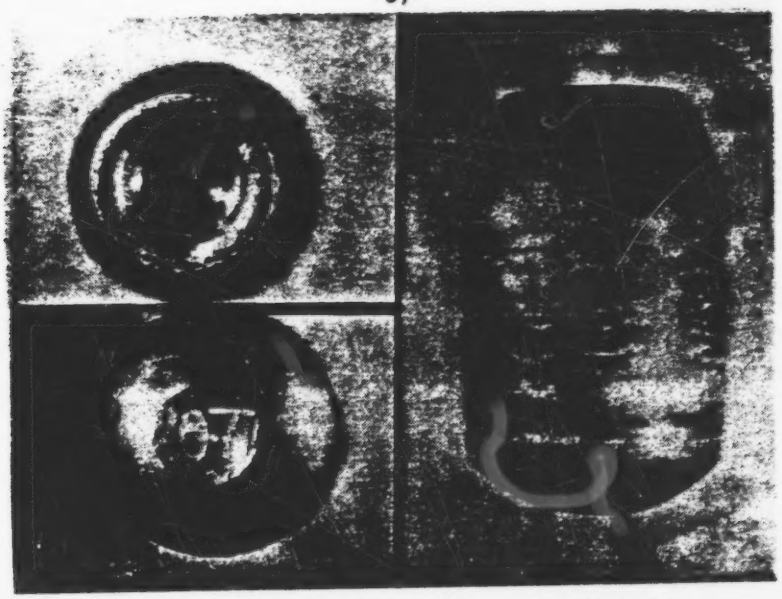
C-182 Capsule Serial Number 2077. 5,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



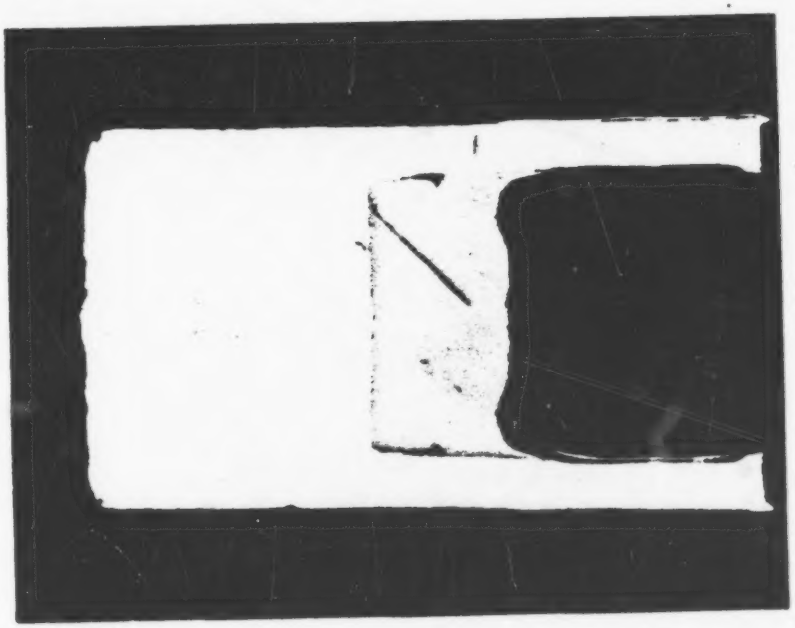
C-182 Capsule Serial Number 2077. 10,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



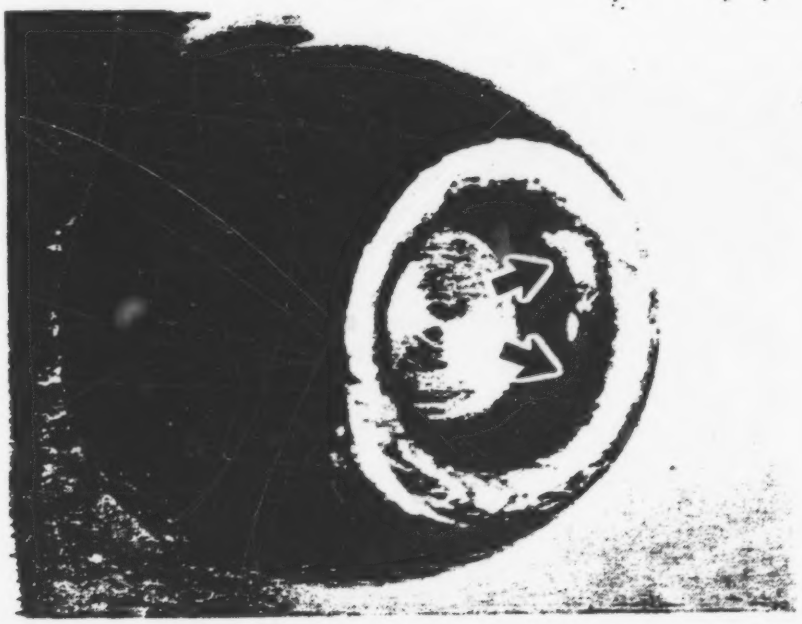
C-182 Capsule Serial Number 2077. 20,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



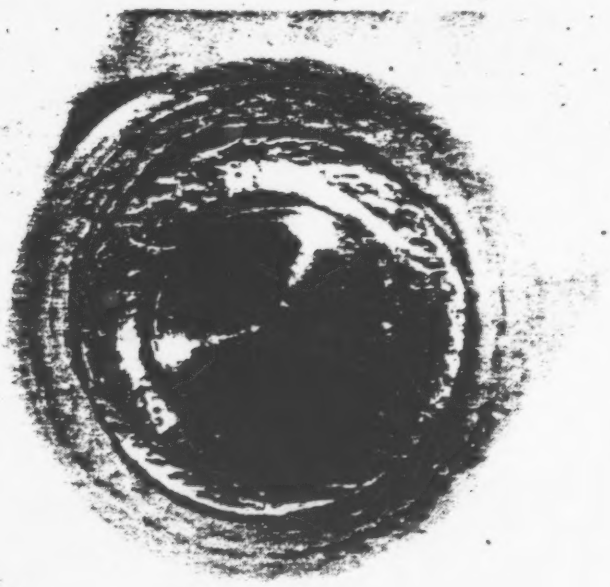
C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end, non weld-end, and side view.
4.7X



C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing cross-section of insert.
12.5X



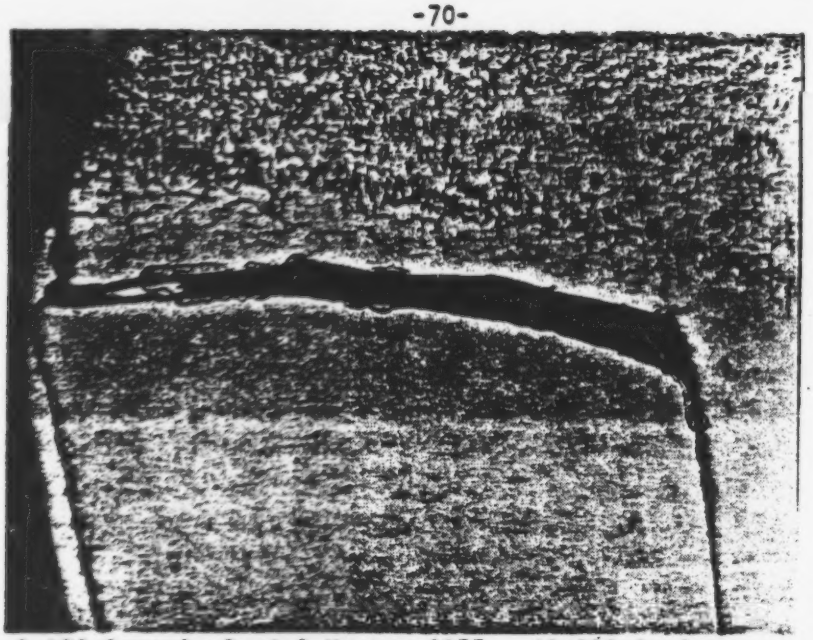
C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing crack located in cap of capsule.
8X



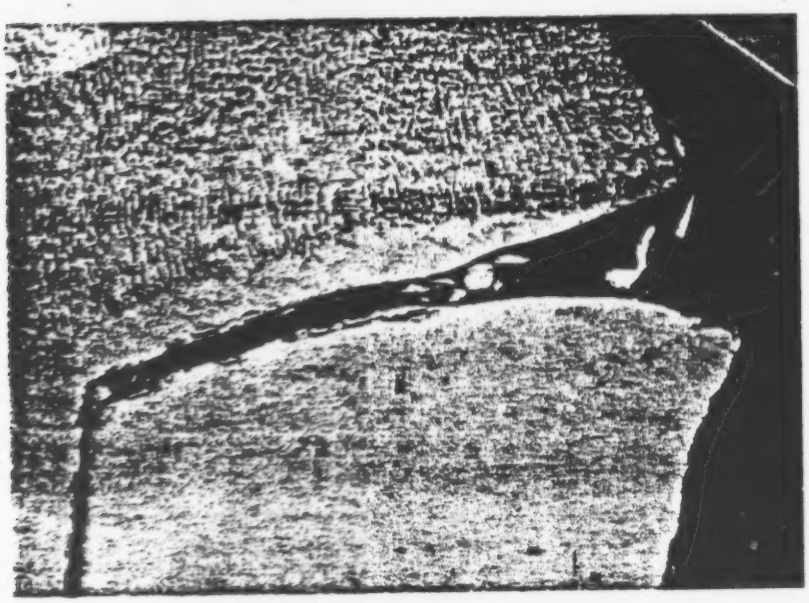
C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing weld end of capsule.
8X

C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

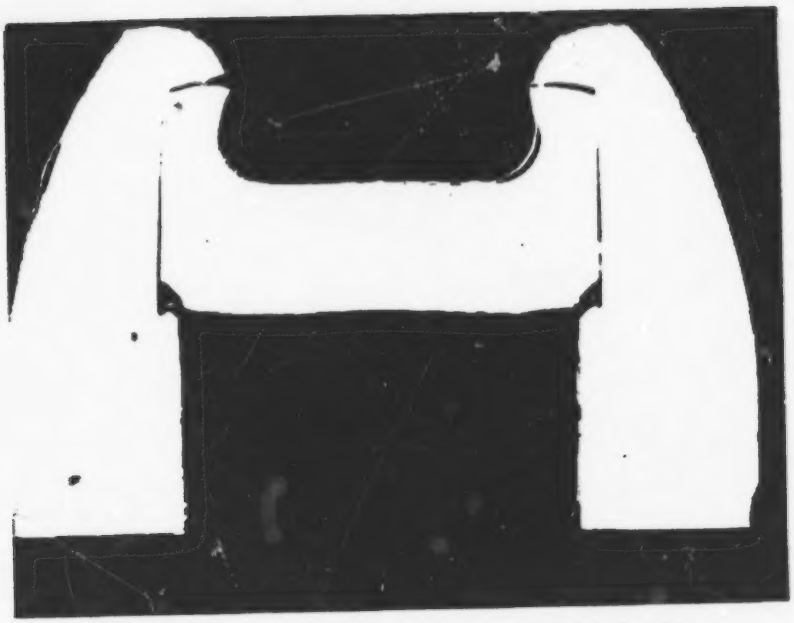
C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomicrograph showing right cross-section of weld microstructure and crack.
125X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomicrograph showing left cross-section of weld microstructure and crack.
125X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2077. 40,000 Cycles.
Reverse orientation and typical field operating conditions.
Photomacrograph showing relative location of crack in welded end of capsule.
12.5X

11. Capsule 2093

Tested to 80,000 cycles in Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.250	8.68	13.50	pass
June 17	5,000	5.248	8.70	13.46	pass
June 21	10,000	5.243	8.76	13.45	pass
July 4	20,000	5.242	8.71	13.49	pass
July 9	40,000	5.241	8.69	13.39	pass
July 16	80,000	5.240	6.70	13.46	pass

Notes:
5000 cycles - flat cap, wear on sides and top

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: 90% continuous indication on weld end of capsule below deformation zone. ie: penetrant is trapped in metal fold caused during cycling. Remainder of capsule satisfactory.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the followinqg observations noted:

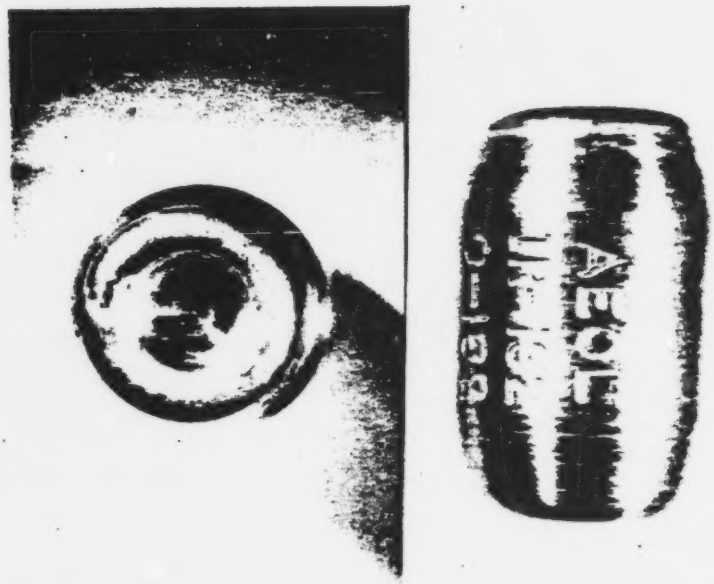
After sectioning the body at the equator, the body separated into two halves. The insert of the capsule was removed from the bottom half of the body and remained intact with the top half (welded end) of the body. The insert was not able to be removed from the top half of the body with fingers. The insert showed a dimpled appearance particularly on the lower outside walls and the bottom face. The corresponding surfaces of the inside surfaces of the bottom half of the body also showed a dimpled appearance. The diameter of the insert at the bottom was 4.52mm.
Under UV examination, no fluorescence was noticed on the insert or the inside of the bottom half of the body.
The insert was removed from the top half (welded end) of the body by holding the insert in a collet and pulling off the body. The contents of the insert could not be removed from the insert itself. The spacer recess distance was 0.55mm.
The length of the insert was 8.08mm.
The diameter of the insert at the top was 4.57mm.

DYE PENETRANT EXAMINATION - INSERT

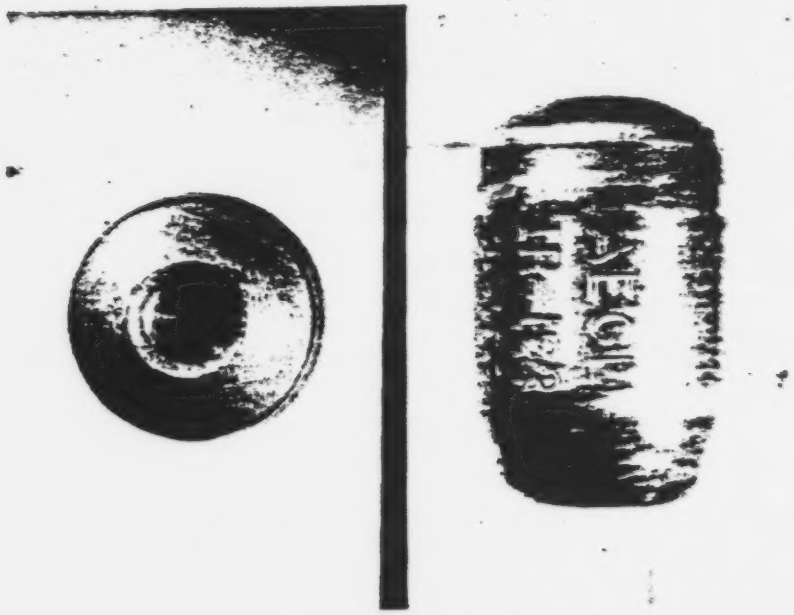
The outside surfaces of the insert were inspectd with a fluorescent dye penetrant to determine if defects were present. Under UV examination, no defects were observed.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

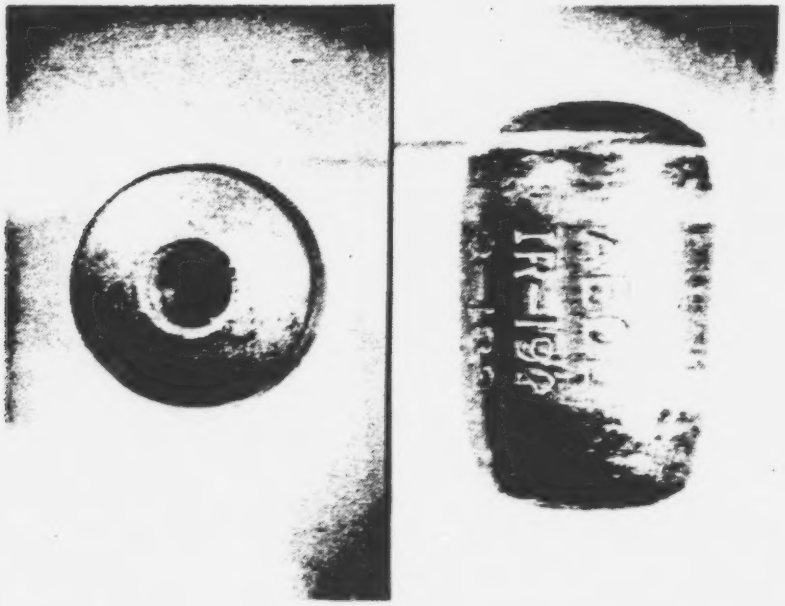
The upper half (welded end) of the body was filled with fluorescent dye penetrant and allowed to stand for 30 minutes. The body (welded half) was examined under UV light for presence of dye penetrant on the outside, and no noticeable amounts were observed.



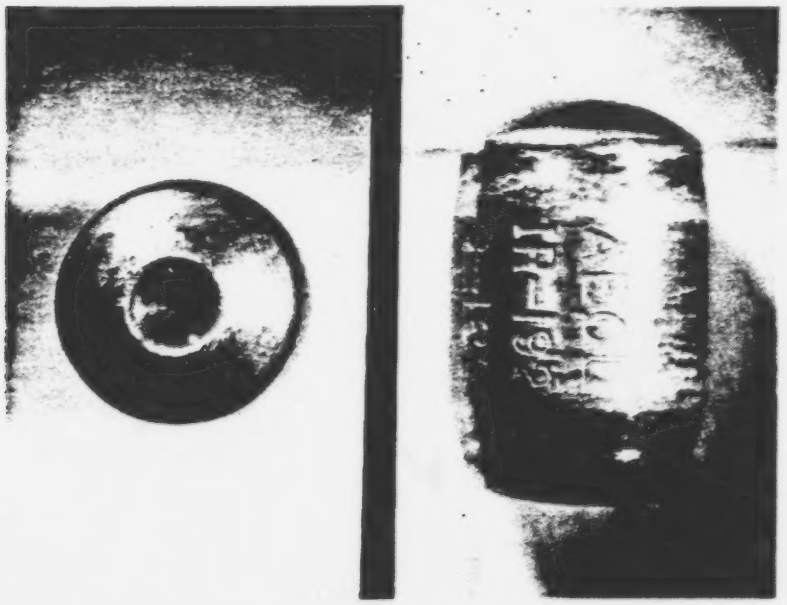
C-182 Capsule Serial Number 2093. As received.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



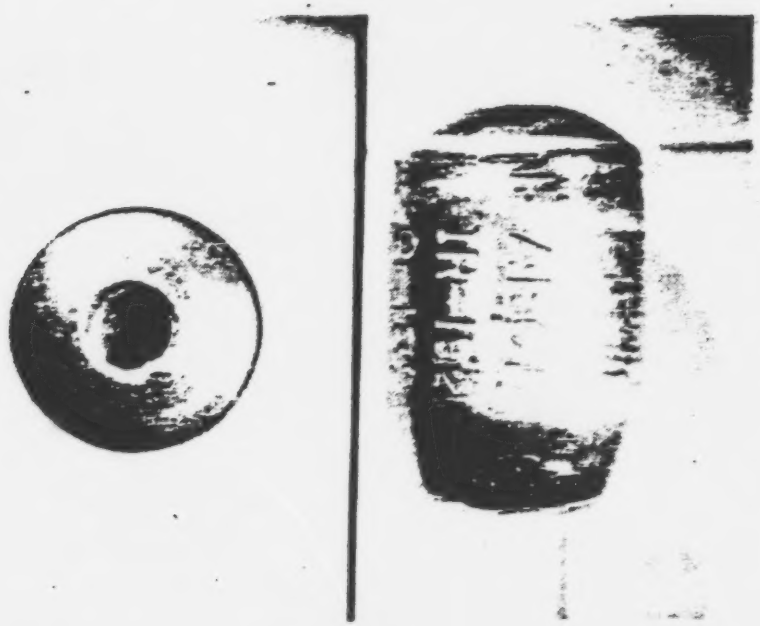
C-182 Capsule Serial Number 2093. 5,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



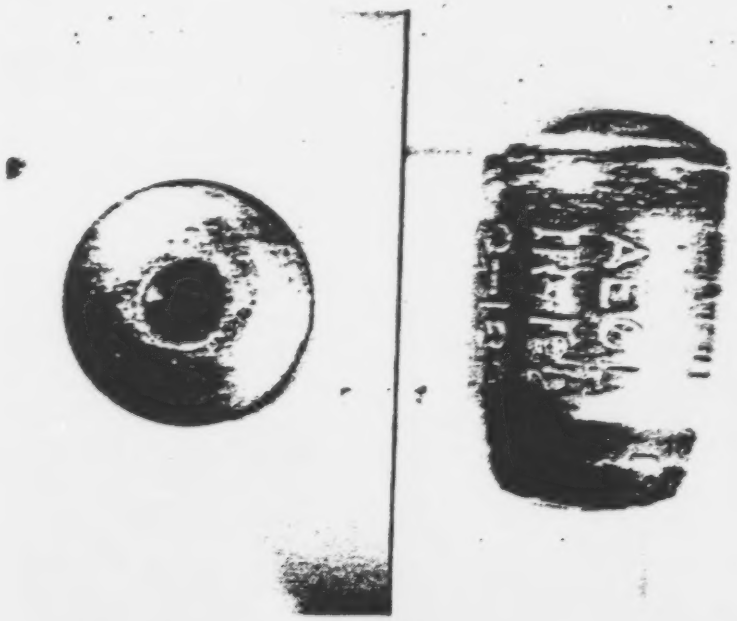
C-182 Capsule Serial Number 2093. 10,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



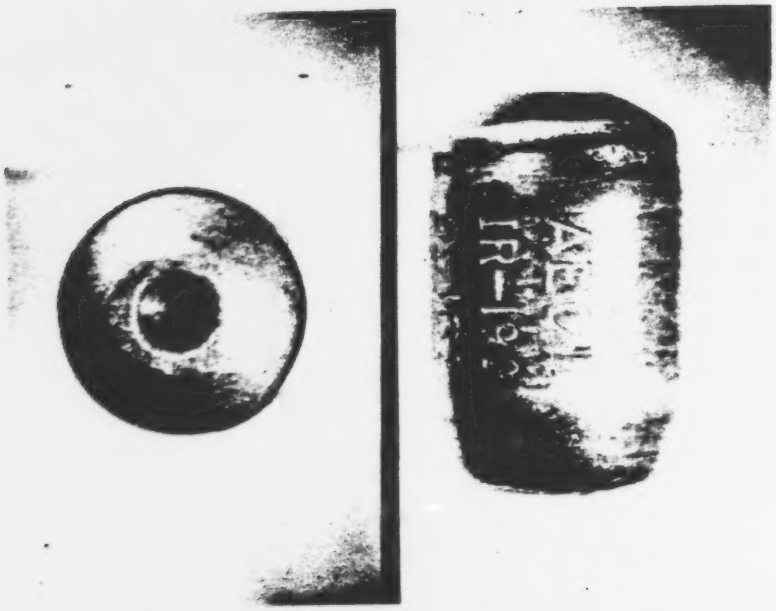
C-182 Capsule Serial Number 2093. 15,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



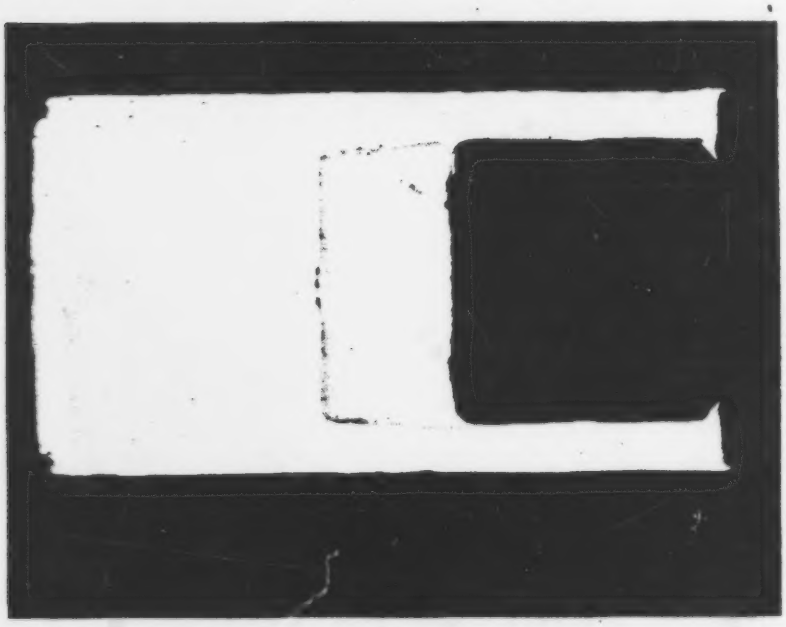
C-182 Capsule Serial Number 2093. 20,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2093. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2093. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2093. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2093. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2093. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

12. Capsule 2087

Tested to 80,000 cycles in Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.238	8.70	13.43	pass
June 17	5,000	5.234	8.70	13.40	pass
June 24	10,000	5.232	8.71	13.40	pass
July 16	15,000	5.231	8.71	13.29	pass
July 18	20,000	5.231	8.71	13.29	pass
July 23	40,000	5.229	8.71	13.30	pass
Aug. 6	80,000	5.226	8.72	13.37	pass

Notes:
- 5000 cycles - wearing around sides and weld top
- flattening to a cap

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: 30% continuous indication on weld end of capsule below deformation zone. Remainder of capsule satisfactory.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

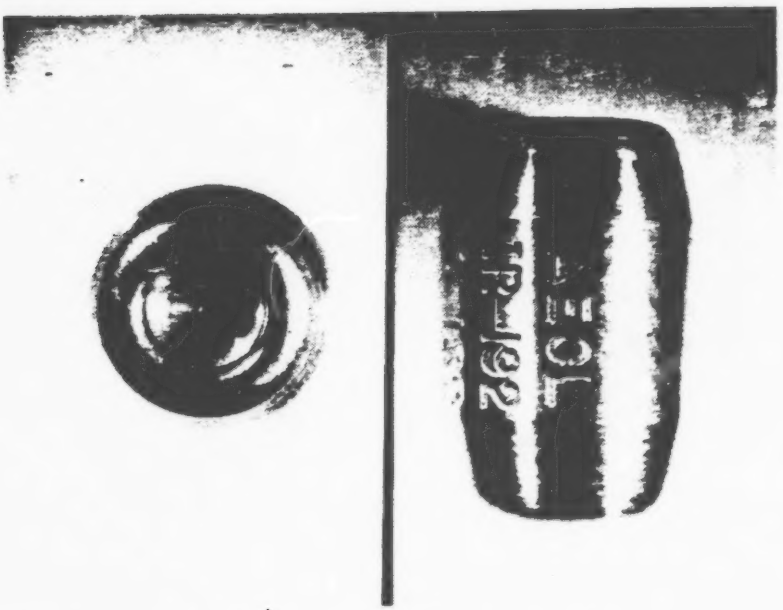
After the body at the equator, the body separated into two halves. The insert of the capsule was removed from the bottom half of the body and remained intact with the top half (welded end) of the body. The insert was not able to be removed by fingers. The outside walls and the bottom face of the insert showed a dimpled appearance. The inside surfaces of the bottom half of the body also showed a dimpled appearance. The diameter of the insert at the bottom was 4.49mm.
Under UV examination, no fluorescence was noted on the outside surfaces of the insert or the inside surfaces of the bottom half of the body. The insert was removed from the top half (welded end) of the body by holding the insert in a collet and pulling the body off the insert. The spacer was removed from the insert, however the shims replacing radioactive material could not be removed from the insert and appeared to be mechanically held in place. The dimensions of the spacer were 3.21mm in diameter and 2.65mm in height. The dimensions of the insert were 4.59mm in diameter at the top and 8.11mm in height.

DYE PENETRANT EXAMINATION - INSERT

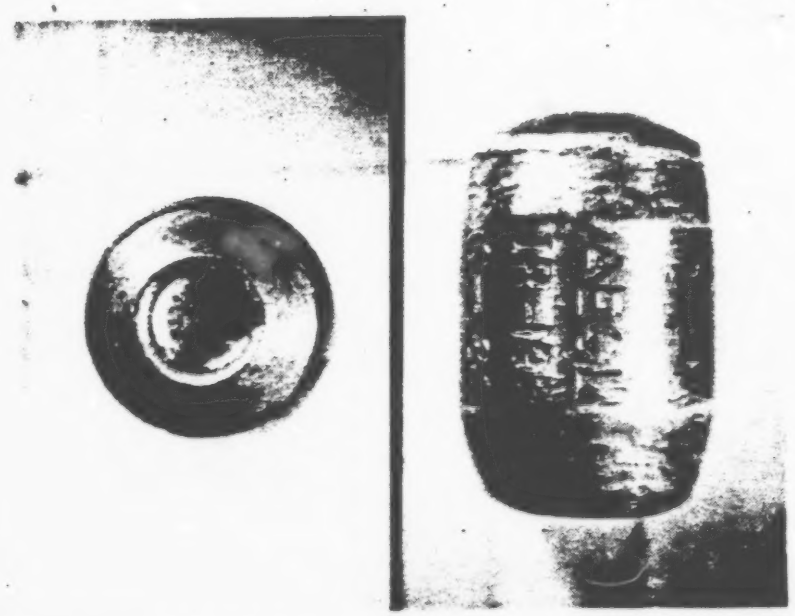
The outside surfaces of the insert were examined for defects using a fluorescent dye penetrant. Under UV examination, no visible indications were present.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

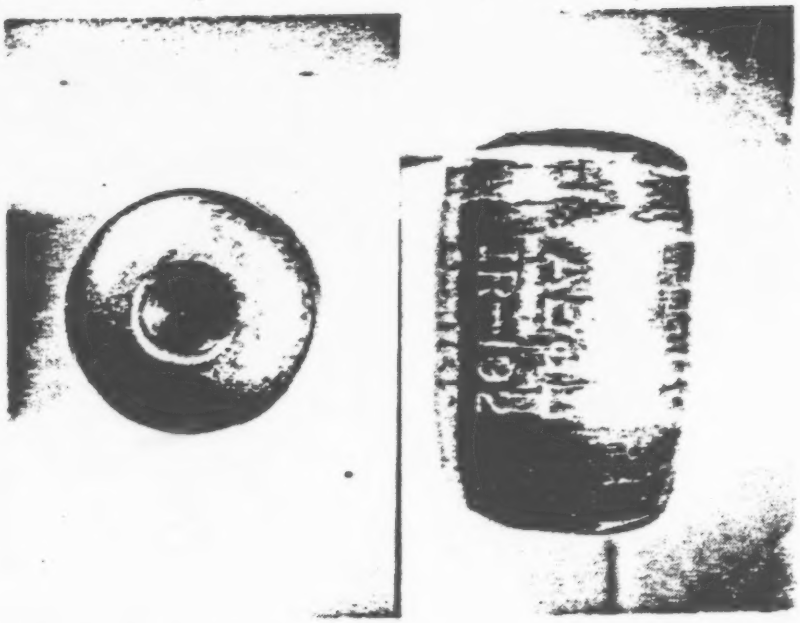
The body (welded end) was also examined for leakage by filling the inner cavity with dye penetrant and allowing the penetrant to soak. The body was examined under UV light, however no dye penetrant was visible on the outer surfaces of the body.



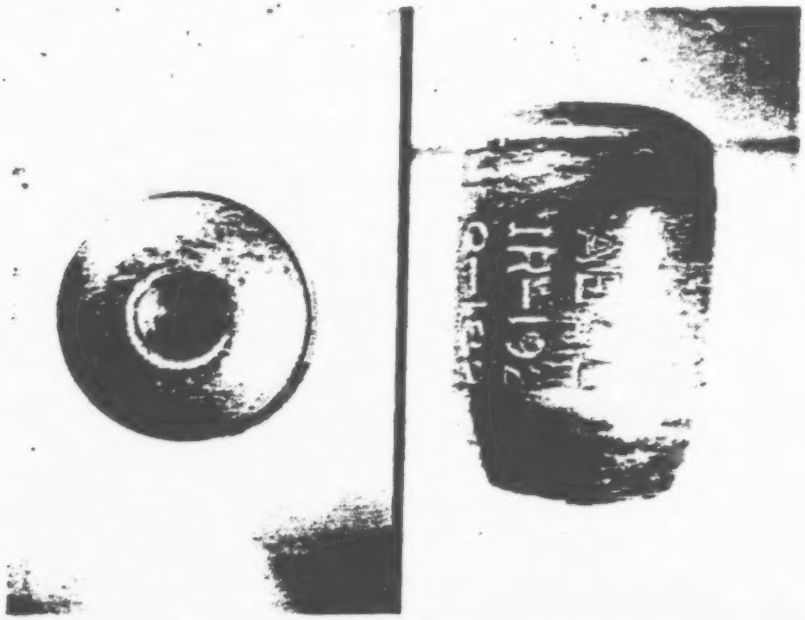
C-182 Capsule Serial Number 2087. As received.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



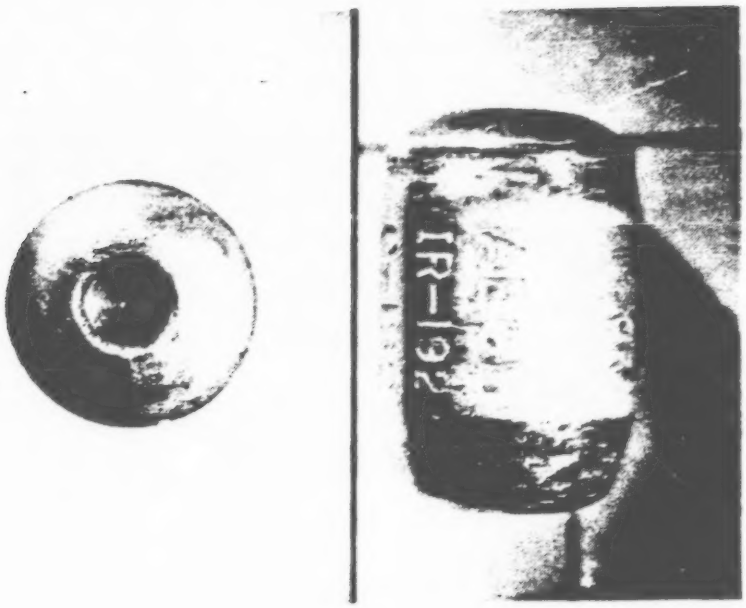
C-182 Capsule Serial Number 2087. 5,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



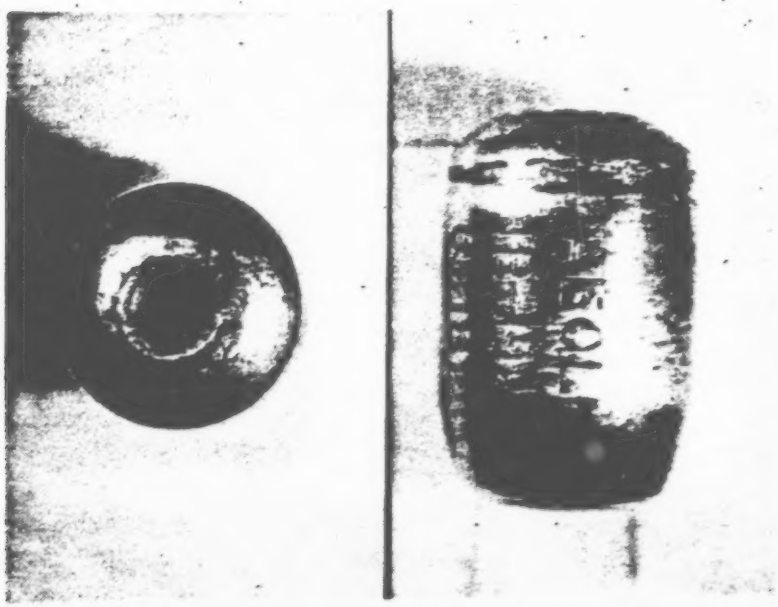
C-182 Capsule Serial Number 2087. 10,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



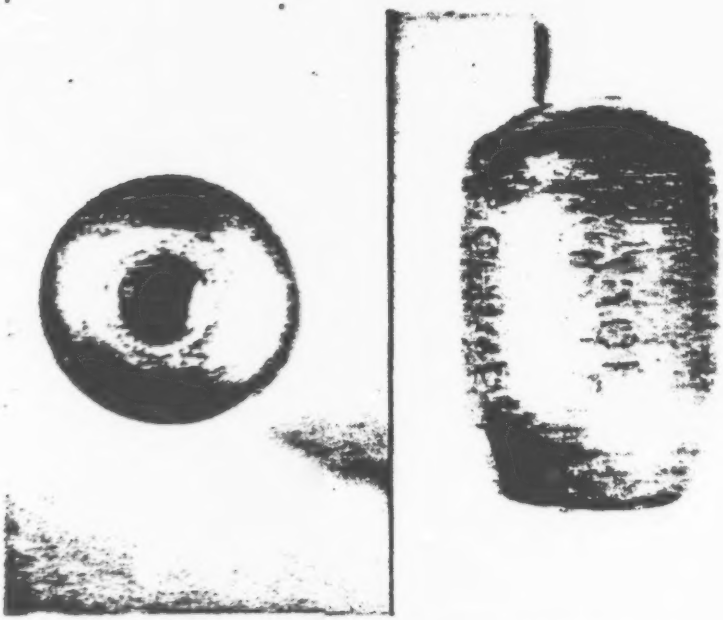
C-182 Capsule Serial Number 2087. 15,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



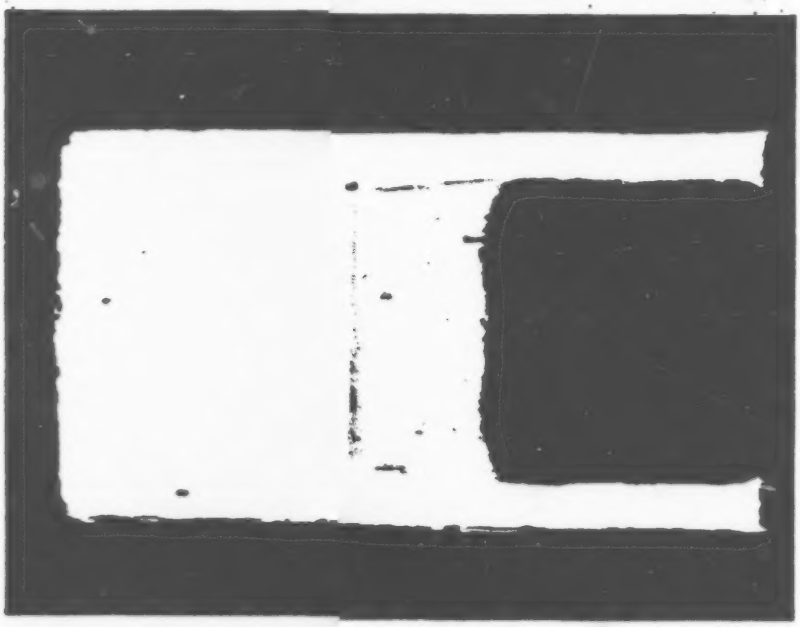
C-182 Capsule Serial Number 2087. 20,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



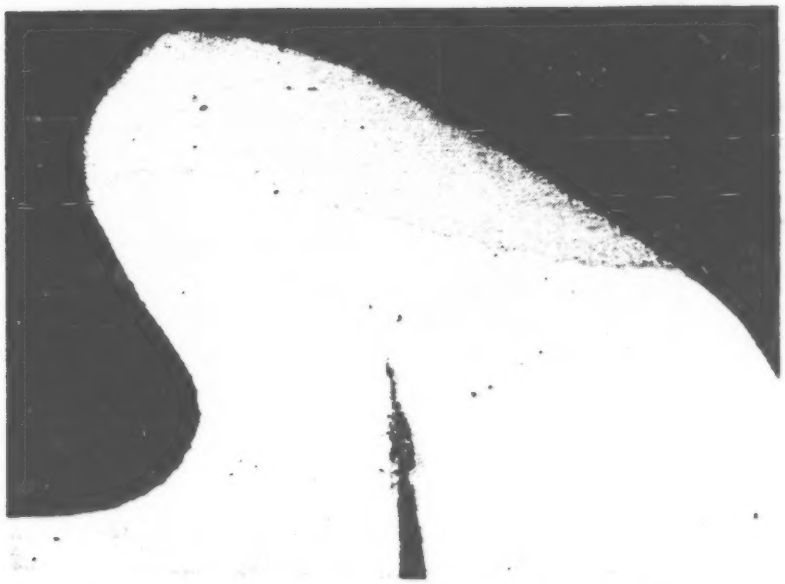
C-182 Capsule Serial Number 2087. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2087. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2087. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of insert.
12.5X



C-182 Capsule Serial Number 2087. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2087. 80,000 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

13. Capsule 2081

Tested to 200,000 cycles in Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
June 1	0	5.239	8.68	13.51	pass
June 14	10,000	5.231	8.70	13.43	pass
June 19	20,000	5.229	8.69	13.43	pass
July 17	30,000	5.228	8.69	13.36	pass
Aug. 5	40,000	5.225	8.68	13.37	pass
Aug. 6	50,000	5.224	8.69	13.38	pass
Aug. 20	100,000	5.222	8.69	13.47	pass
Sept. 23	160,200	5.214	8.70	13.59	pass

Notes:

10,000 cycles - weld end flattened considerably causing a cap effect

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: 80% indication on weld end of capsule below deformation zone at metal fold as a result of cycling. Remainder of capsule satisfactory.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

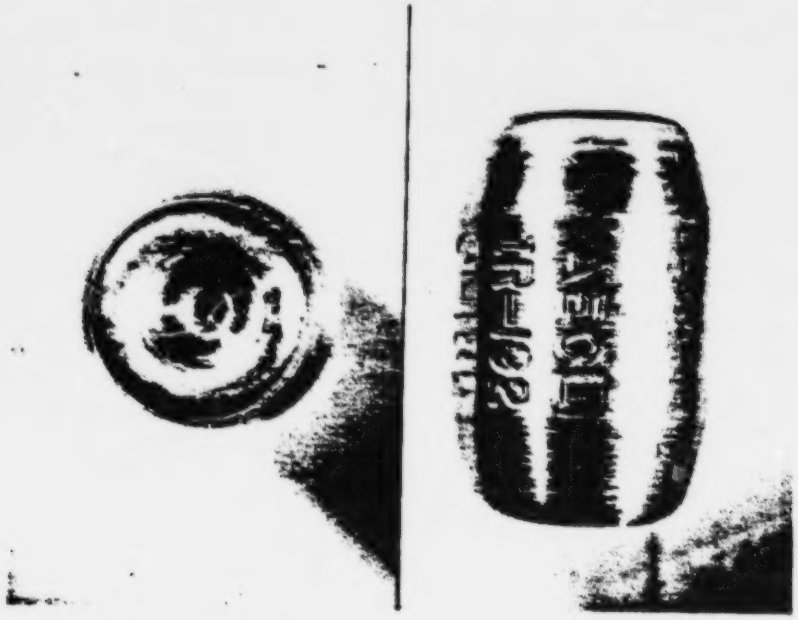
After sectioning the body at the equator, the capsule was separated into two halves. A recognizable insert was not noticed in either halve of the body. A spherical shaped metal object was the only item which was removed from the body. The dimensions of the metal sphere are 2.82mm in height and 3.26mm in diameter. It appears as though the insert has been deformed to the extent of being mechanically attached to the body, however this account will be examined further metallurgically. Under UV observation, no fluorescence was detected on the inside surfaces of the capsule.

DYE PENETRANT EXAMINATION - INSERT

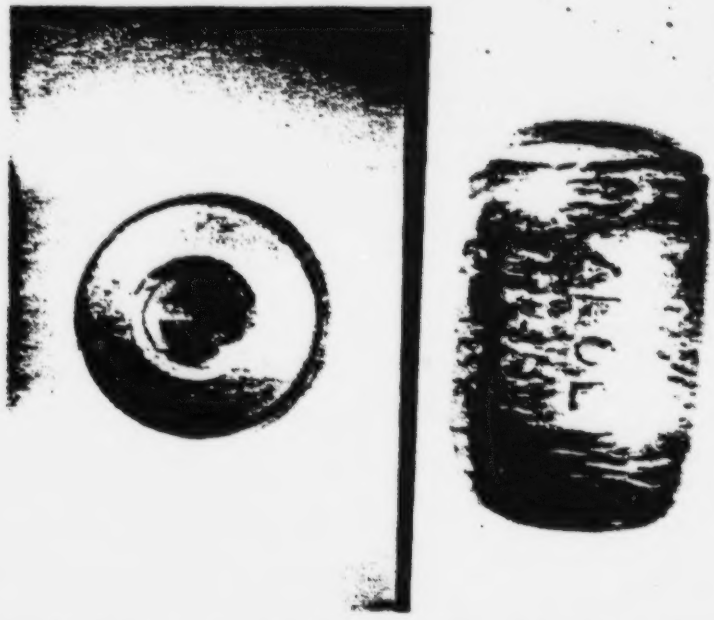
The outside surfaces of the insert of the capsule could not be dye penetrant tested since the insert was not 'recognizable' after sectioning the capsule at the equator.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

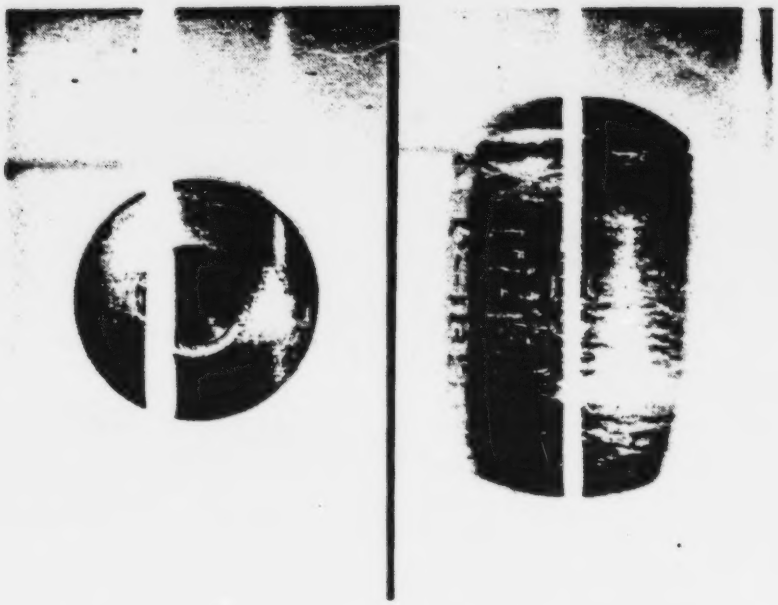
The top half (weld end) of the cavity was filled with dye penetrant and allowed to soak for 30 minutes. The capsule was examined under UV light in order to determine if dye penetrant was allowed to penetrate through the capsule. No dye penetrant was noticed on the outside of the body.



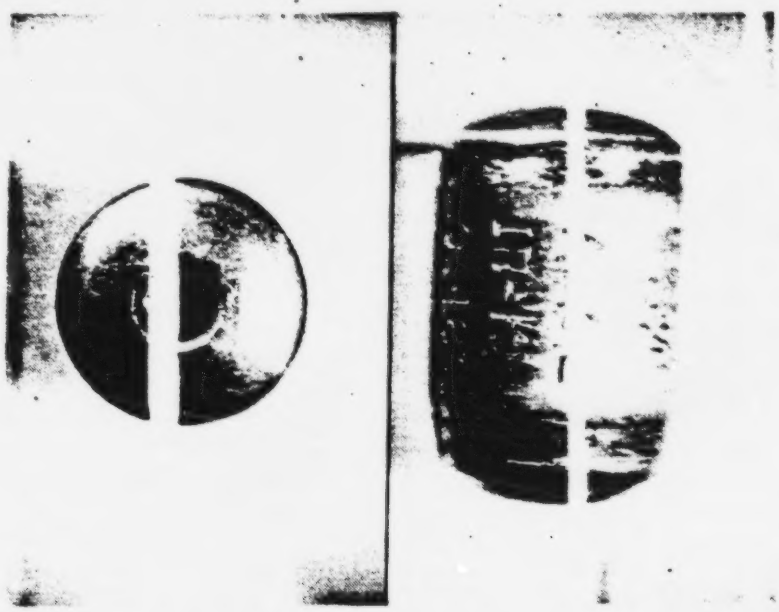
C-182 Capsule Serial Number 2081. As received.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2081. 10,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

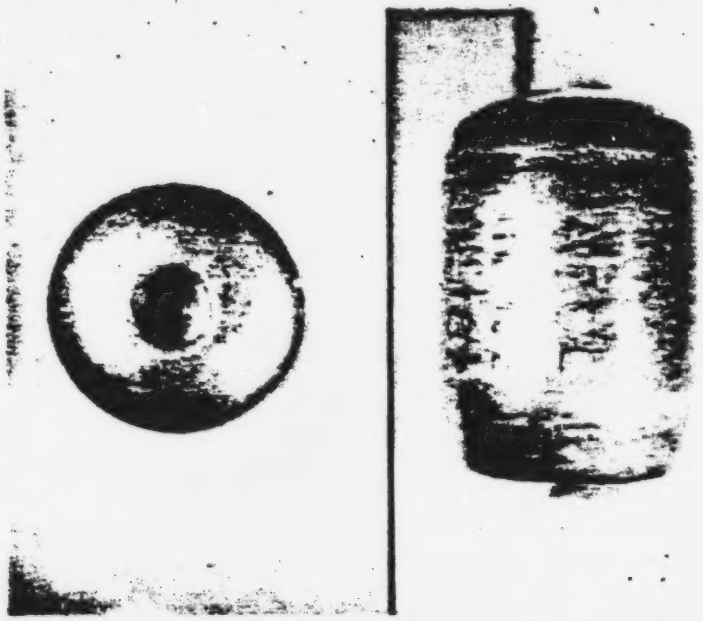


C-182 Capsule Serial Number 2081. 20,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

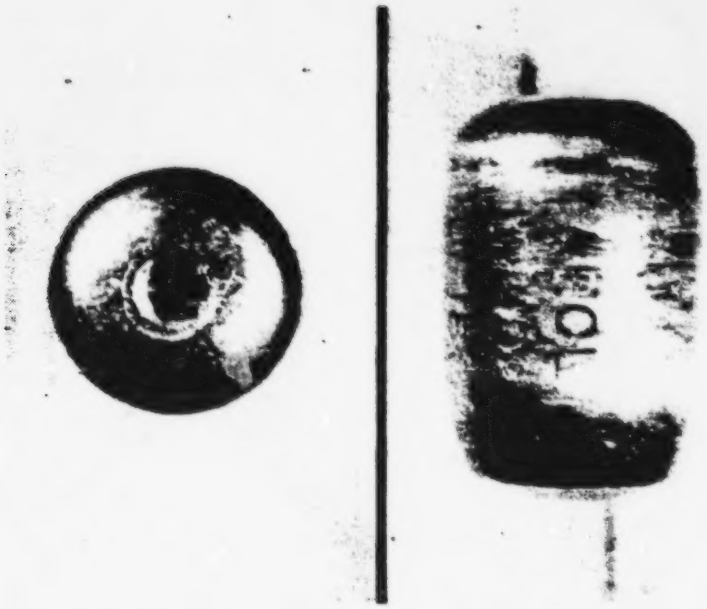


C-182 Capsule Serial Number 2081. 30,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X

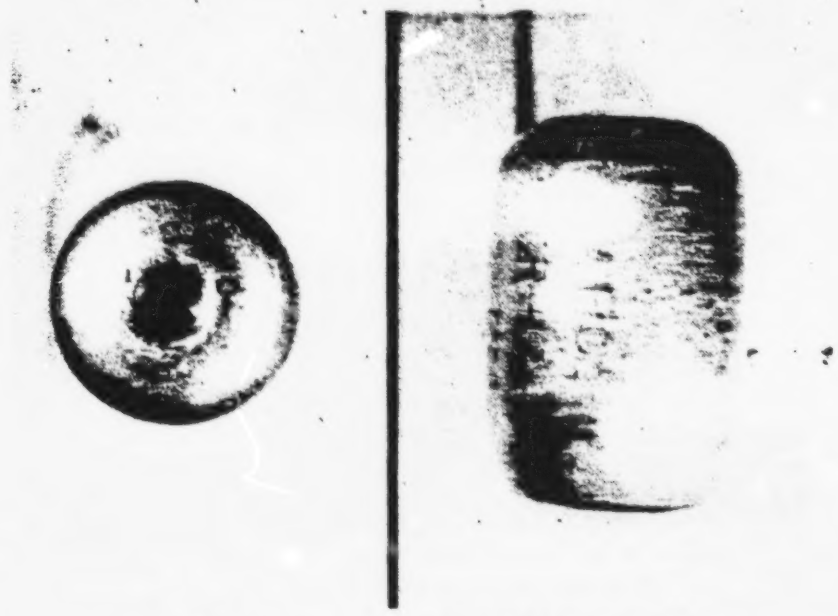
C-182 Capsule Serial Number 2081. 40,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



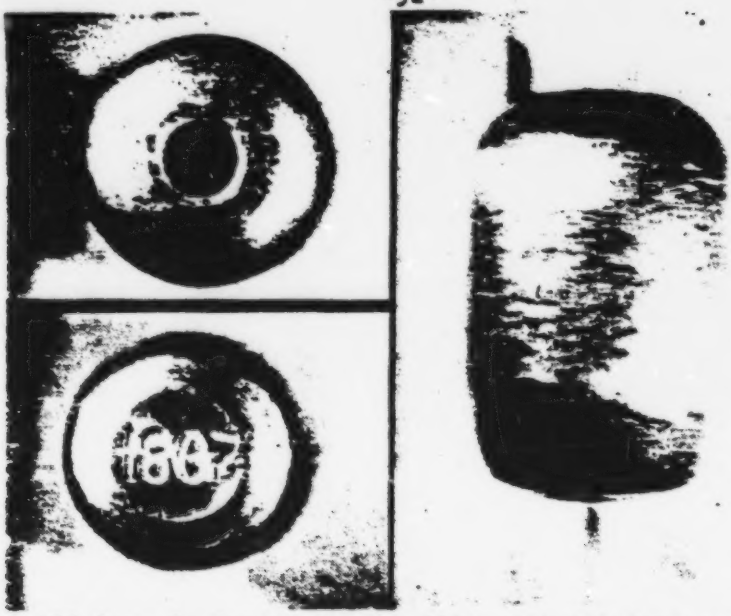
C-182 Capsule Serial Number 2081. 50,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



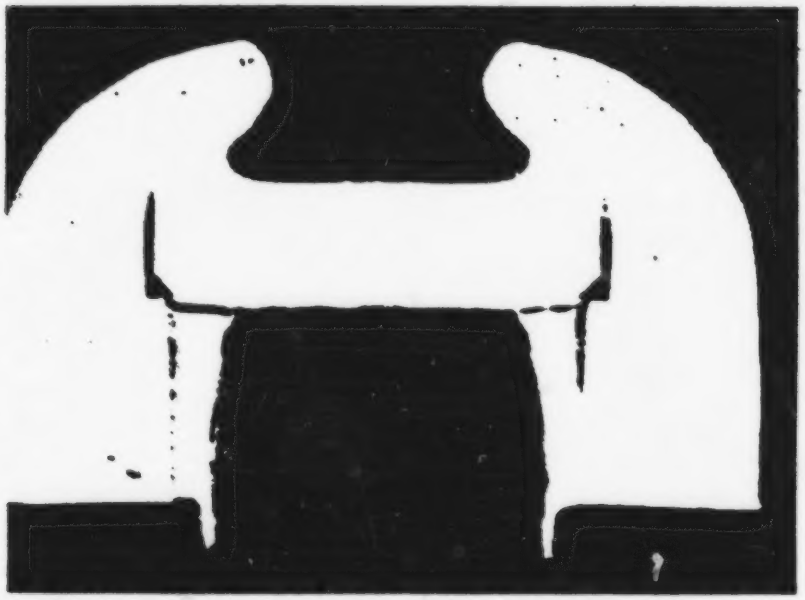
C-182 Capsule Serial Number 2081. 100,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



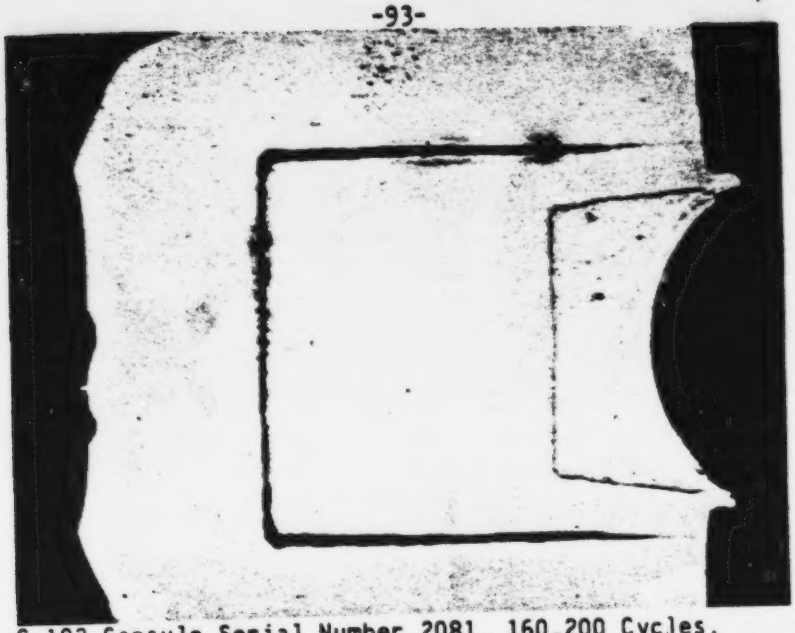
C-182 Capsule Serial Number 2081. 150,000 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2081. 160,200 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing welded end, nonwelded end, and side view.
4.7X



C-182 Capsule Serial Number 2081. 160,200 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of welded end of capsule.
12.5X



C-182 Capsule Serial Number 2081. 160,200 Cycles.
Normal orientation and typical field operating conditions.
Photomacrograph showing cross-section of nonwelded end of capsule.
12.5X

C-182 Capsule Serial Number 2081. 160,200 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2081. 160,200 Cycles.
Normal orientation and typical field operating conditions.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

14. Capsule 2082

Tested to 10,000 cycles in Normal Orientation

with two 45 Degree Bends in Headhose

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.264	8.69	13.50	pass
Aug. 30	250	5.264	8.69	13.56	pass
Aug. 30	500	5.264	8.69	13.59	pass
Aug. 30	1,000	5.264	8.68	13.61	pass
Aug. 30	2,000	5.264	8.68	13.62	pass
Sept. 3	5,000	5.264	8.69	13.68	pass
Sept. 19	10,000	5.263	8.70	14.14	pass

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: No visible indications on outside of capsule.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

After sectioning the body at the equator, the insert separated from the bottom of the body and remained intact with the top (welded end) of the body. A dimpled appearance was noticed on the bottom and side walls of the insert. A corresponding appearance was noted on the inside walls of the body.

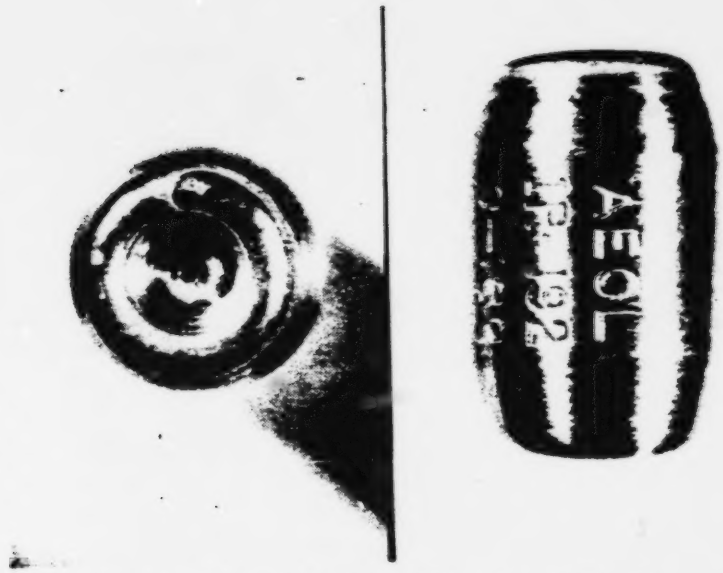
Diameter of insert 4.47mm (Bottom), 4.625mm (Top)
Length of insert = 8.25mm
Under UV inspection, no fluorescence was detected on the inside surfaces of the capsule. The insert was removed by holding the insert in a collet and pulling off the body.

DYE PENETRANT EXAMINATION - INSERT

The outside surfaces of the insert were inspected with dye penetrant. Under UV examination, no indications were noted.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

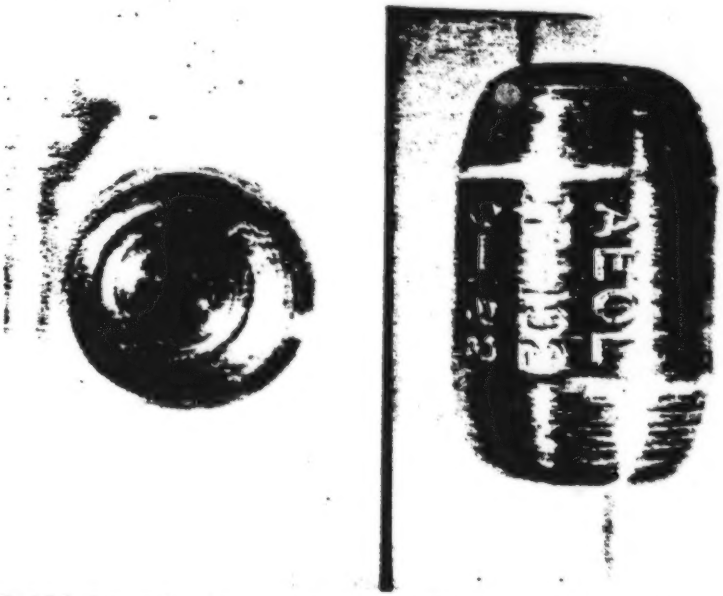
Dye penetrant was also applied to the inside cavity of the welded end of the body, to determine if dye pentrant would penetrate from the inside to the outside of the capsule. Under UV examination, no dye penetrant leakage was observed.



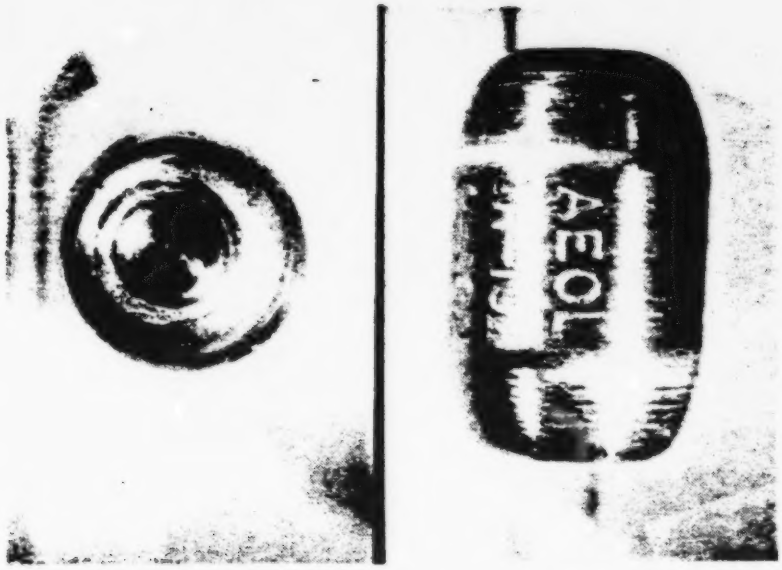
C-182 Capsule Serial Number 2082. As received.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2082. 250 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X

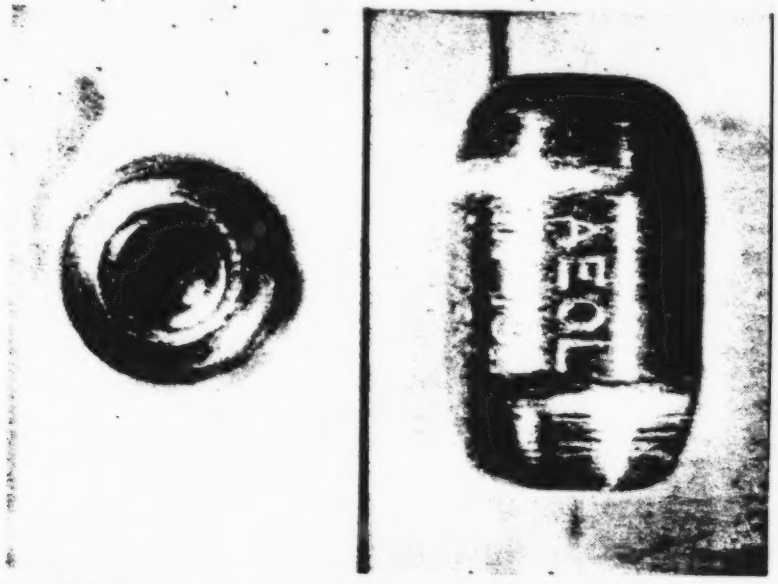
C-182 Capsule Serial Number 2082. 500 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X



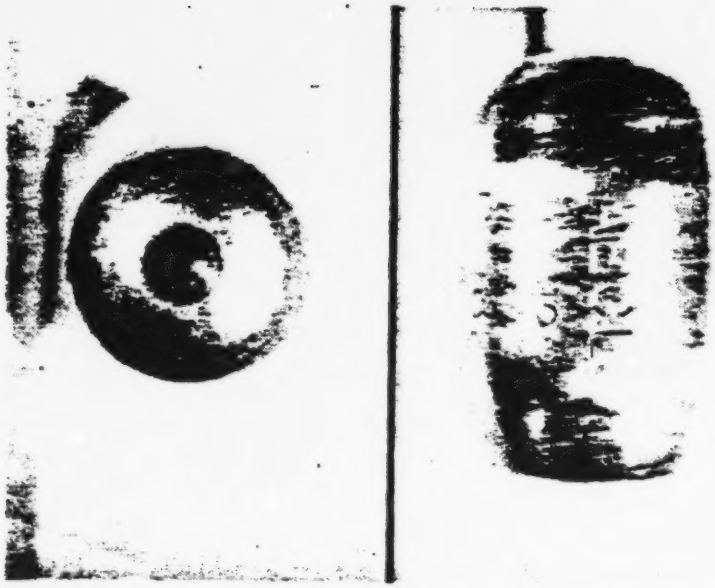
C-182 Capsule Serial Number 2082. 1,000 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X



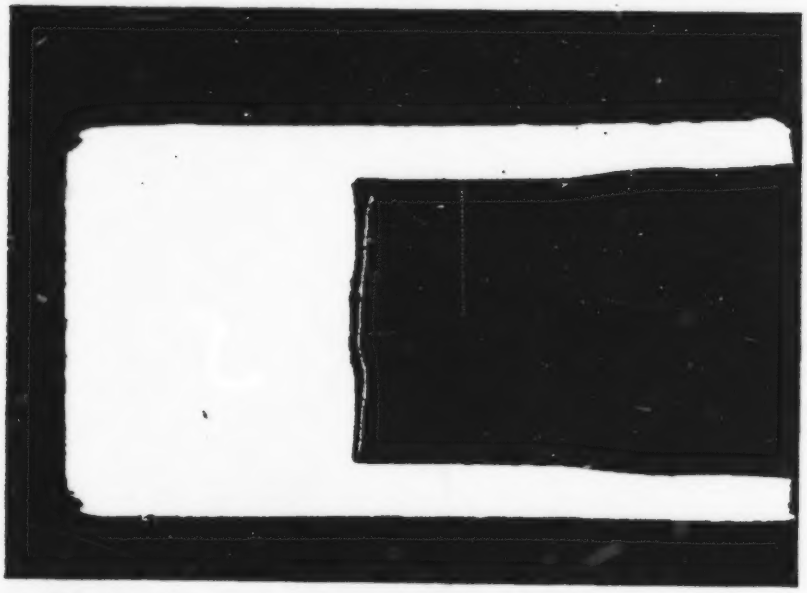
C-182 Capsule Serial Number 2082. 2,000 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2082. 5,000 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2082. 10,000 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2082. 10,000 Cycles.
Normal orientation and typical field operating conditions
with two 45 degree bends in the head hose.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2082. 10,000 Cycles.
Normal orientation and typical field operating conditions with two 45 degree bends in the head hose.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2082. 10,000 Cycles.
Normal orientation and typical field operating conditions with two 45 degree bends in the headhose.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

15. Capsule 2084

Tested to 40,000 in Normal Orientation Pipeline Mode

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.260	8.69	13.44	pass
Aug. 21	250	5.260	8.69	13.43	pass
Aug. 21	500	5.260	8.69	13.42	pass
Aug. 22	1,000	5.260	8.69	13.42	pass
Aug. 22	2,000	5.260	8.69	13.42	pass
Aug. 22	5,000	5.259	8.69	13.42	pass
Aug. 22	10,000	5.259	8.69	13.42	pass
Aug. 27	20,000	5.260	8.69	13.43	pass
	40,000	5.254	8.69	13.45	pass

Notes:

250 cycles - little deformation, only dirty

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: No visible indications on outside of capsule.

SECTIONING CAPSULES AT EQUATOR

Procedure:

Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

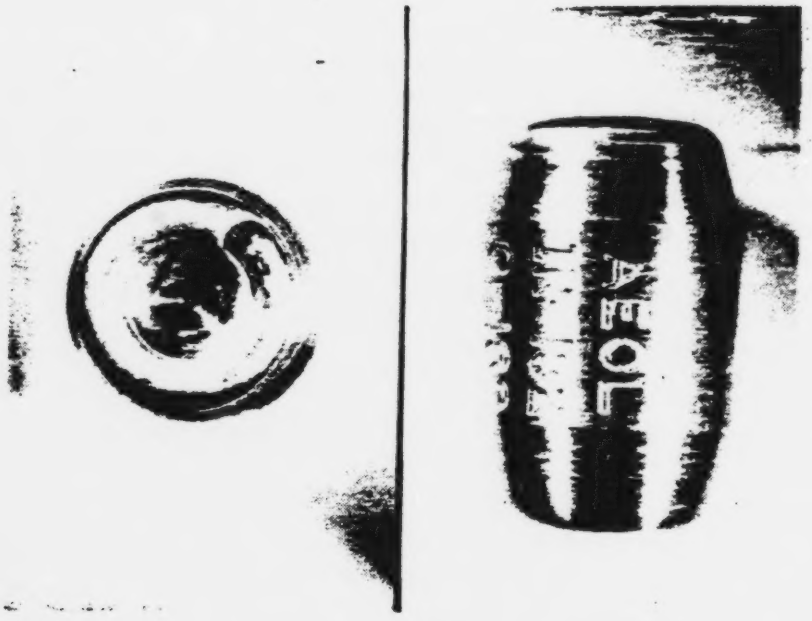
After sectioning the capsule at the equator, the inner capsule was able to be removed from the bottom of the outer capsule and remained in the top (welded half) of the outer capsule. No noticable deformation, i.e. dimpling, etc., was observed on the bottom half of either the inner or outer capsule.
Inner Capsule diameter = 4.51mm (Bottom) 4.50mm (Top)
Under UV inspection, no fluorescence was detected on the inner surfaces of the capsule.
The insert was able to be removed by securing the insert in a collet and pulling the body off.
Spacer 2.56mm high, 3.15mm diameter
Insert length = 8.04mm
Shims 1.09mm high, 2.97mm diameter

DYE PENETRANT EXAMINATION - INSERT

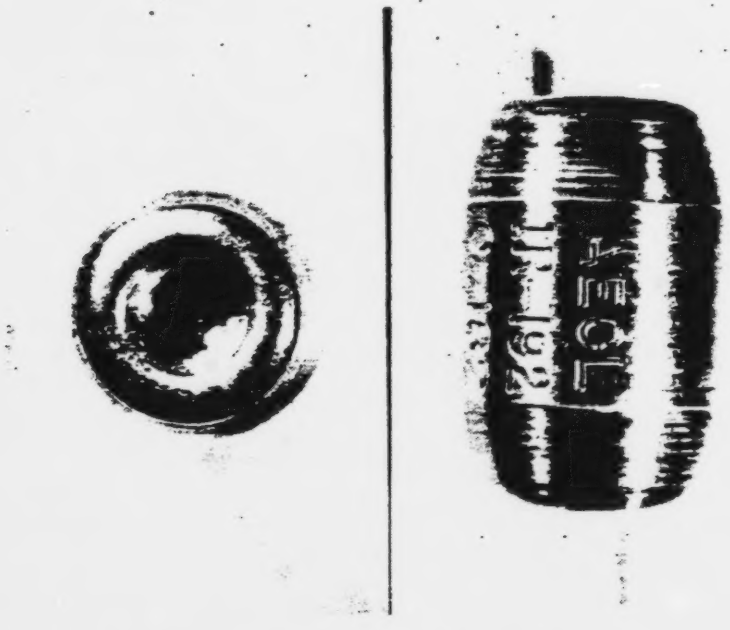
The outside surfaces of the insert were inspected with fluorescent dye penetrant. The insert was examined under UV light and no defects were observed.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

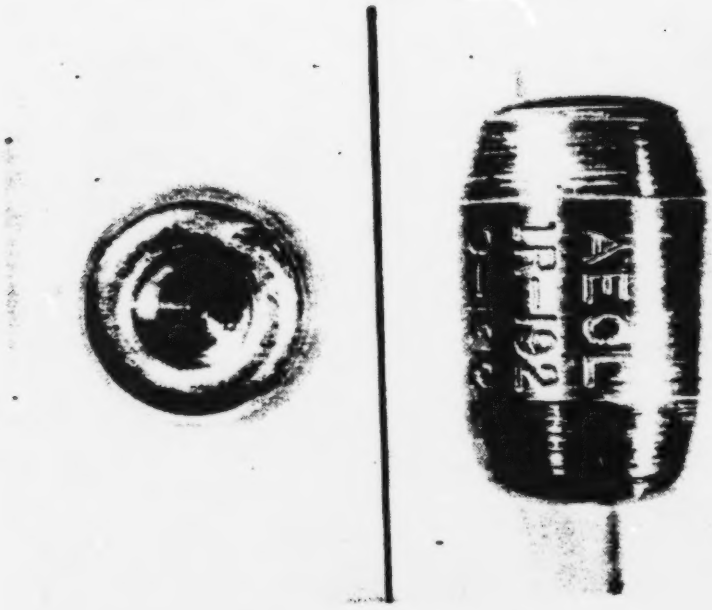
Dye penetrant was applied to the inside cavity of the welded end of the body. The penetrant was allowed to soak in the inside of the capsule. The outside surfaces of the body were examined under UV light and no penetrant was observed on the outside of the capsule.



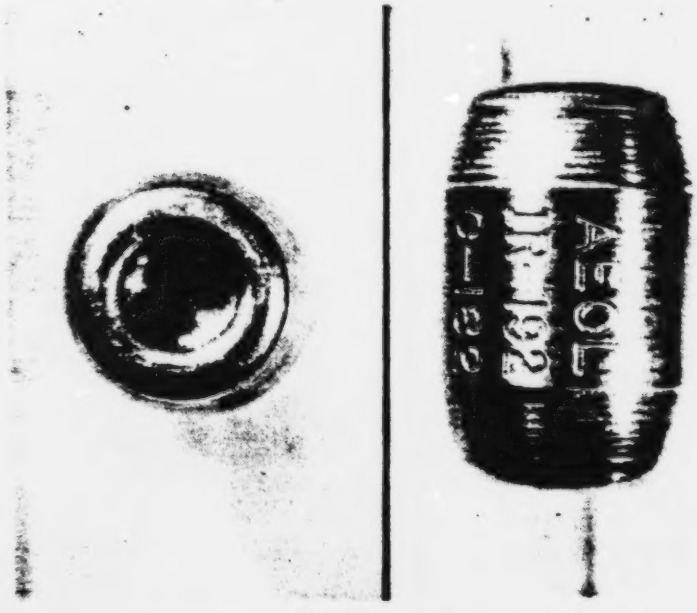
C-182 Capsule Serial Number 2084. As received.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



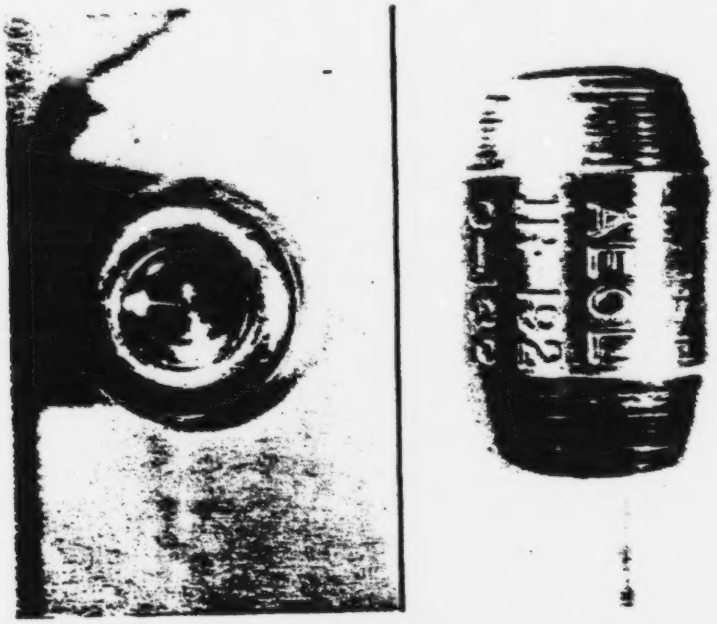
C-182 Capsule Serial Number 2084. 250 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



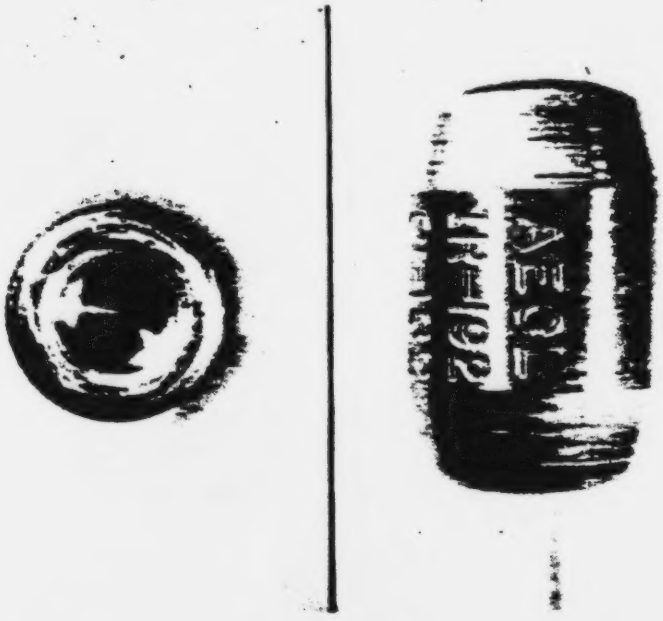
C-182 Capsule Serial Number 2084. 500 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



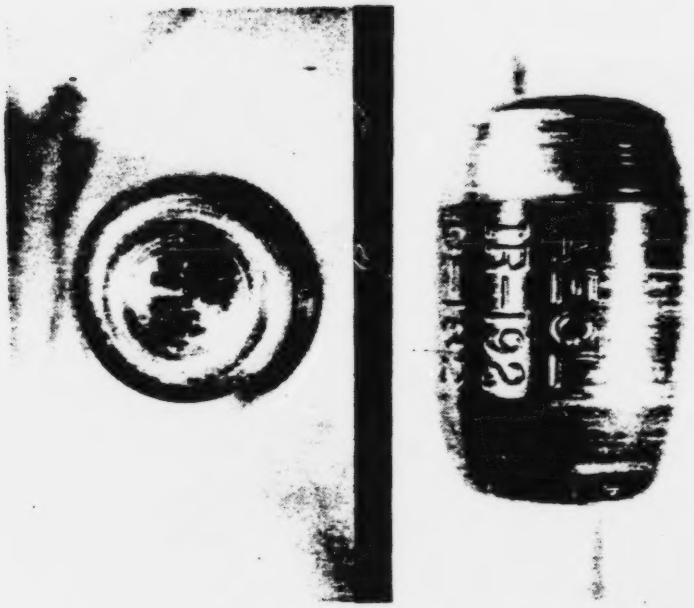
C-182 Capsule Serial Number 2084. 1,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



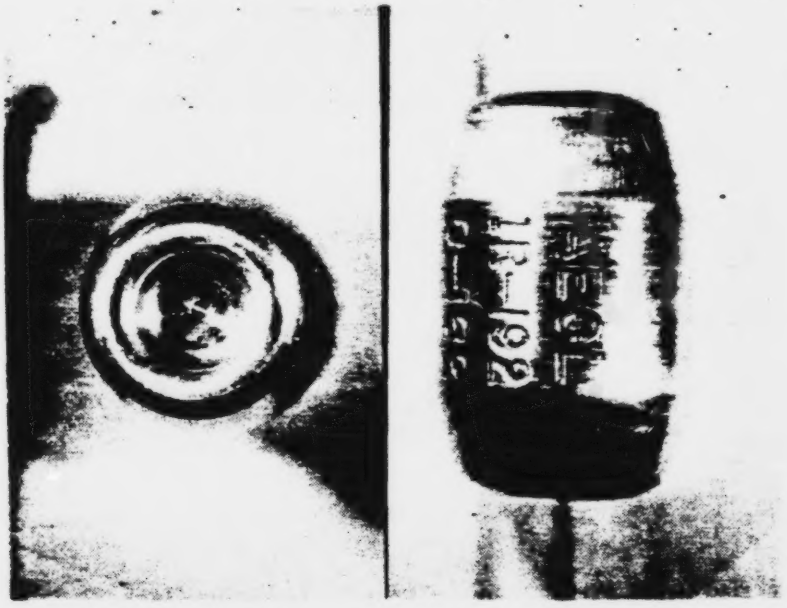
C-182 Capsule Serial Number 2084. 2,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



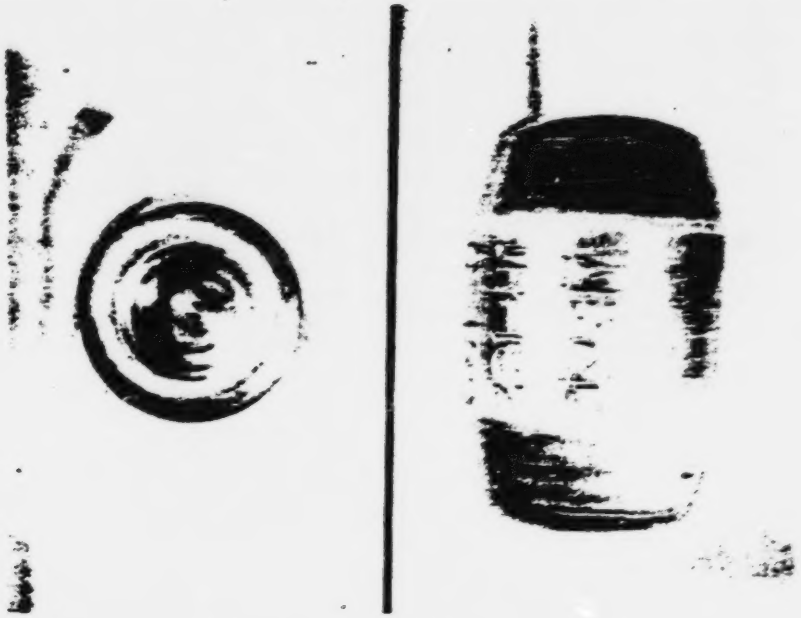
C-182 Capsule Serial Number 2084. 5,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



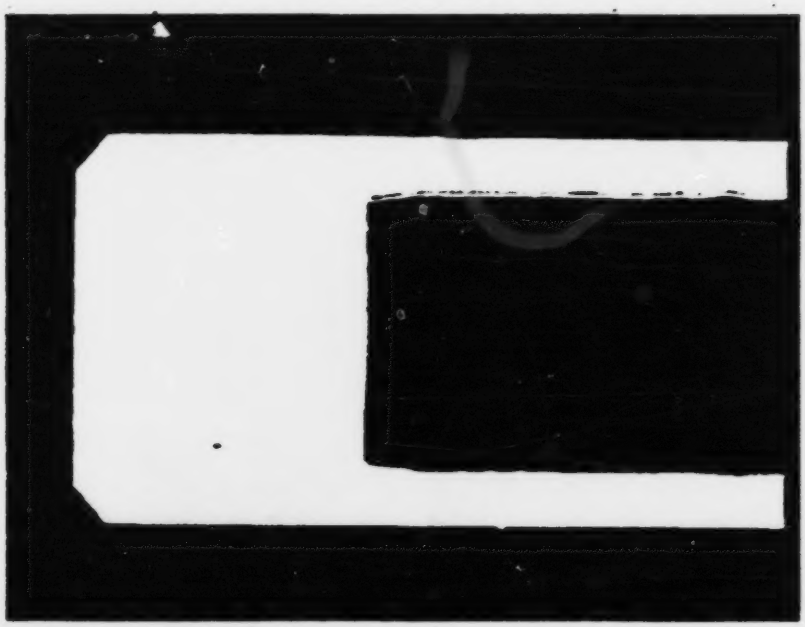
C-182 Capsule Serial Number 2084. 10,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2084. 20,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2084. 40,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2084. 40,000 Cycles.
Normal orientation and pipeline mode.
Photomacrograph showing cross-section of insert.
12.5X

C-182 Capsule Serial Number 2084. 40,000 Cycles.
Normal orientation and pipeline mode.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2084. 40,000 Cycles.
Normal orientation and pipeline mode.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

16. Capsule 2080

Tested to 40,000 cycles in Reverse Orientation in Pipeline Mode

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.245	8.69	13.48	pass
Sept. 4	250	5.245	8.68	13.45	pass
Sept. 4	500	5.244	8.68	13.45	pass
Sept. 4	1,000	5.244	8.68	13.45	pass
Sept. 4	2,000	5.244	8.68	13.44	pass
Sept. 4	5,000	5.244	8.68	13.45	pass
Sept. 5	10,000	5.243	8.69	13.45	pass
Sept. 6	20,000	5.243	8.69	13.45	pass
Sept. 11	40,000	5.243	8.69	13.45	pass

Notes:

- Capsule becomes gummy
- Scratches are noticeable on sides (particularly on tapered sides)

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: No visible indications on outside of capsule.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

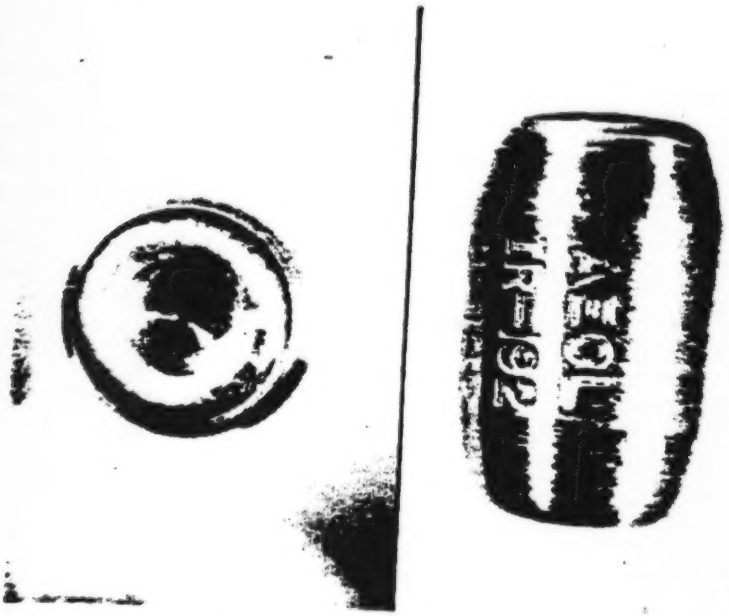
After sectioning the body at the equator, the body separated into two parts. The insert was able to be removed from both the top and bottom of the body. The insert did not show any characteristic dimpling as noted in some other inserts. All contents of the insert were removed and appeared in good condition. The dimensions of the insert were 4.475mm diameter and 8.10mm long. The dimensions of the spacer were 2.585mm high and 3.15mm diameter. The dimensions of the two spacers substituting radioactive material were 1.08mm thick and 3.02mm in diameter. Under UV examination, no internal components of the capsule showed fluorescence, thus it is assumed no defects were present to allow dye penetrant penetration from the outside of the capsule.

DYE PENETRANT EXAMINATION - INSERT

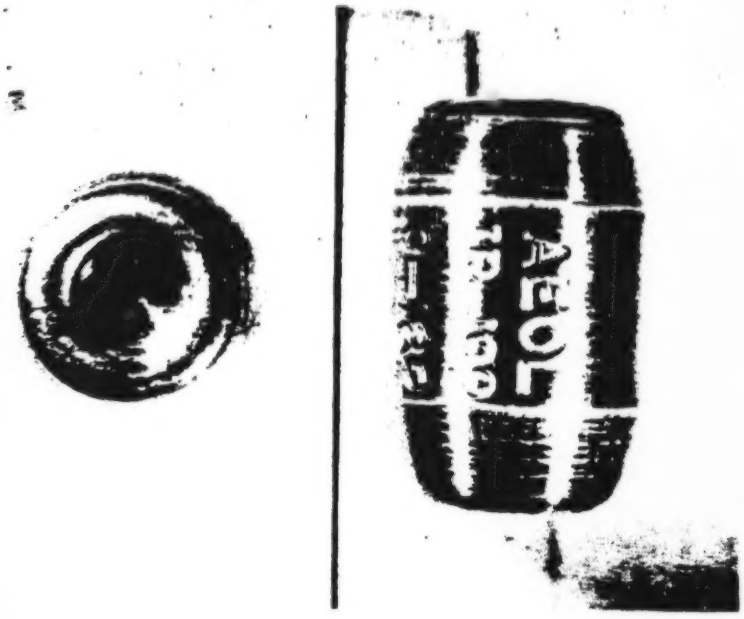
The outside surfaces of the insert were examined for defects using a fluorescent dye penetrant. After soaking in penetrant, the insert was examined under UV light and no defects were noted.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

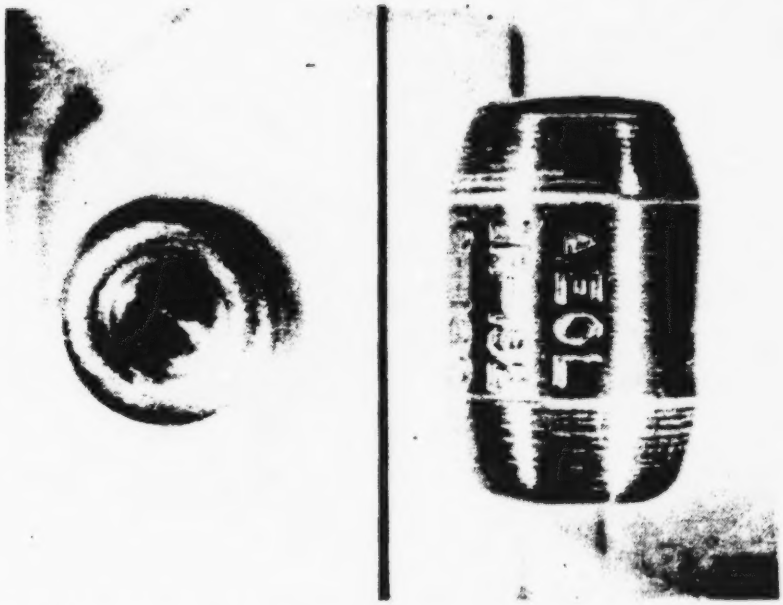
The upper half (welded end) of the body was tested using a fluorescent dye penetrant. The penetrant was applied to the inside cavity of the body and allowed to soak. After soaking, the outside surfaces of the capsule were examined under a UV light and no evidence of dye penetrant on the outside of the capsule was observed.



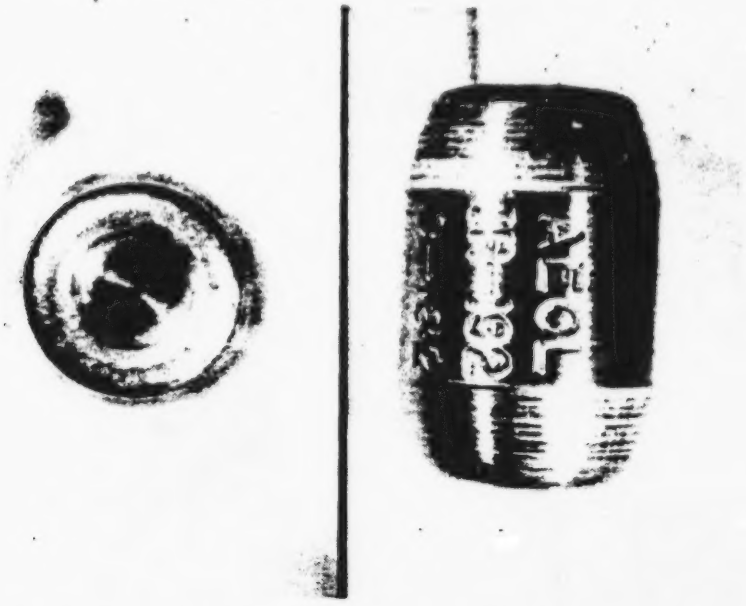
C-182 Capsule Serial Number 2080. As received.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



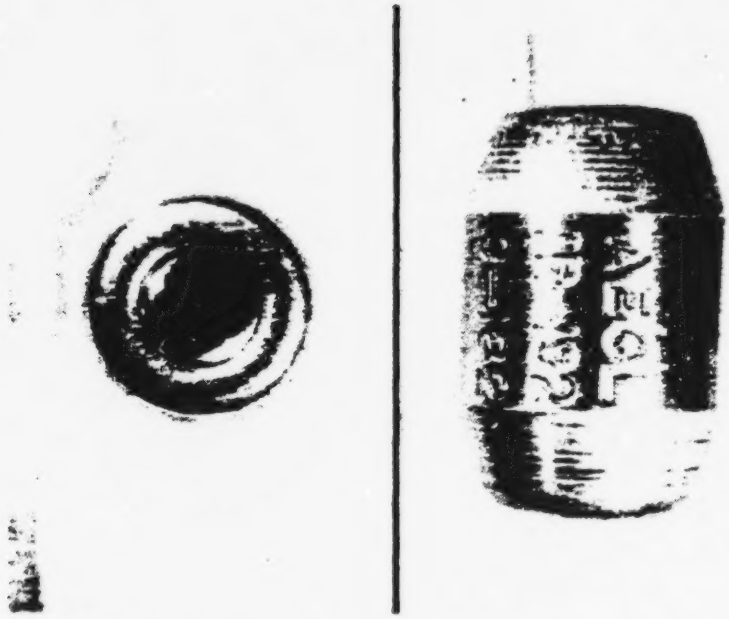
C-182 Capsule Serial Number 2080. 250 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



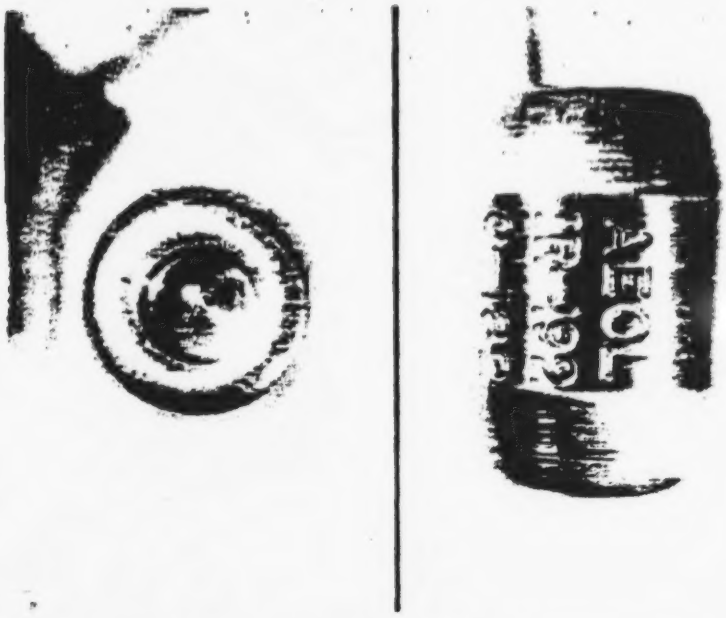
C-182 Capsule Serial Number 2080. 500 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2080. 1,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2080. 2,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X

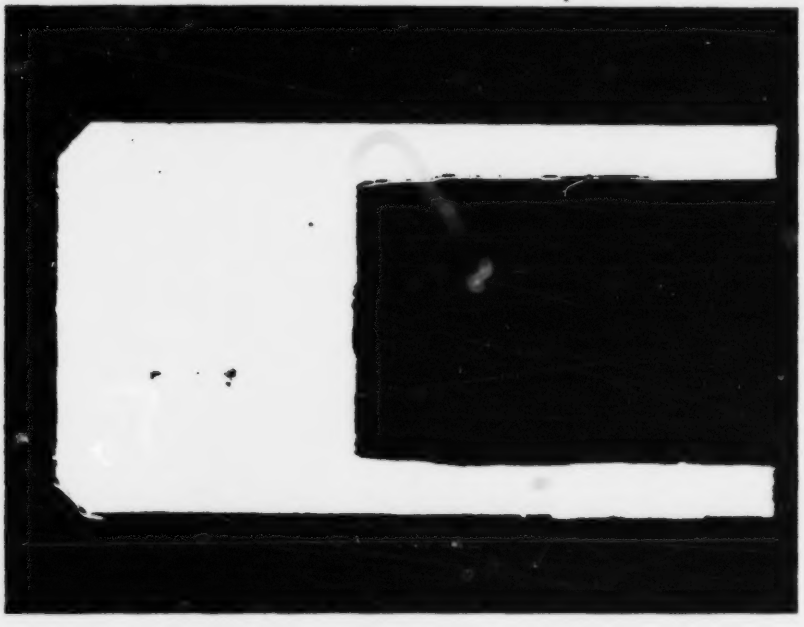


C-182 Capsule Serial Number 2080. 5,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X

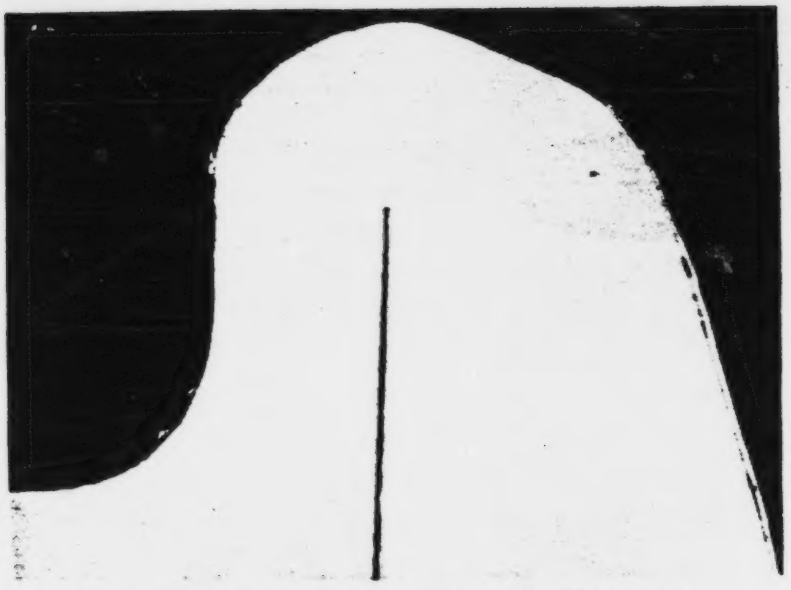
C-182 Capsule Serial Number 2080. 10,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X

C-182 Capsule Serial Number 2080. 20,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X

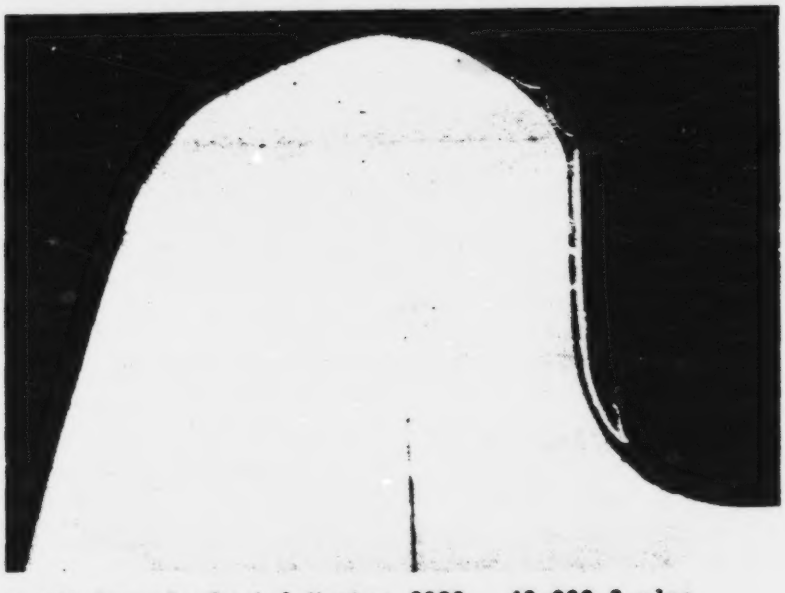
C-182 Capsule Serial Number 2080. 40,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing weld end and side view.
4.7X



C-182 Capsule Serial Number 2080. 40,000 Cycles.
Reverse orientation and pipeline mode.
Photomacrograph showing cross-section of insert.
12.5X



C-182 Capsule Serial Number 2080. 40,000 Cycles.
Reverse orientation and pipeline mode.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid



C-182 Capsule Serial Number 2080. 40,000 Cycles.
Reverse orientation and pipeline mode.
Photomicrograph showing left cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic Acid

17. Capsule 2079

Tested to 40,000 cycles with Headhose

Cushion Removed-Normal Orientation

DATE	NUMBER OF CYCLES	WEIGHT (g)	DIAMETER (mm)	HEIGHT (mm)	BUBBLE TEST (pass/fail)
April 24	0	5.251	8.69	13.48	pass
July 23	250	5.250	8.70	13.61	pass
July 23	500	5.249	8.70	13.66	pass
July 26	1,000	5.249	8.70	13.76	pass
July 31	2,000	5.248	8.71	14.07	pass
Aug. 6	5,000	5.247	8.72	14.27	pass
Aug. 8	10,000	5.244	8.72	14.46	pass
Aug. 14	20,000	5.241	8.72	15.14	pass
Aug. 27	40,000	5.237	8.73	15.60	pass

DYE PENETRANT EXAMINATION - OUTSIDE SURFACE OF CAPSULE

Procedure: Capsules were soaked in fluorescent dye penetrant for 10 minutes, cleaned with cleaner, sprayed with developer and the outside surfaces were examined under ultraviolet light for defects.

Results: No visible indications on outside of capsule.

SECTIONING CAPSULES AT EQUATOR

Procedure: Capsules were placed in the collet of a lathe (unwelded end held) and parted. Width of parting tool = 0.60mm. Capsules were parted such that only the outer capsule was cut into two pieces. The inner capsule and contents remained intact. The capsules were examined and the following observations noted:

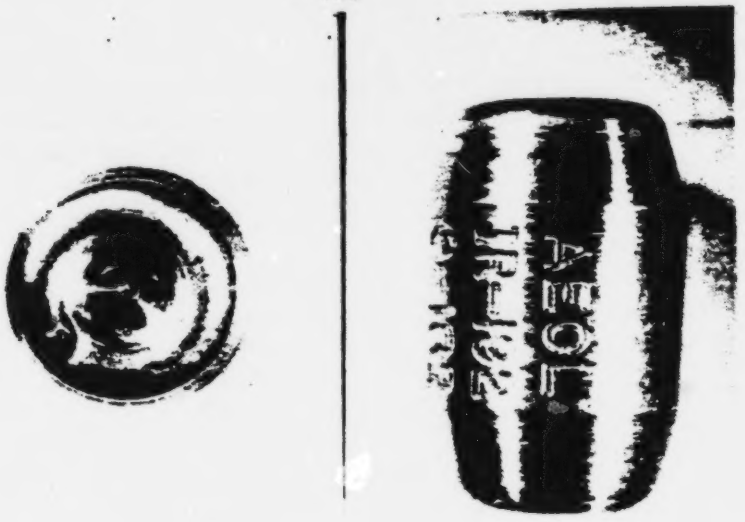
After sectioning the body at the equator, the capsule was separated into two halves. The insert separated from the bottom of the body while remaining intact with the upper (welded end) half of the body. The bottom of the insert and in particular the bottom face of the insert contained a dimpled appearance. The diameter of the insert at the bottom was 4.48mm. The insert could not be removed from the body by fingers.
Under UV examination, no fluorescence was noted on the outside surfaces of the exposed insert and the inside surfaces of the bottom half of the body.
An attempt was made to remove the insert from the top half (welded end) of the body by holding the insert in a collet, however even under relatively high pulling forces, the insert and body could not be separated from the body.

DYE PENETRANT EXAMINATION - INSERT

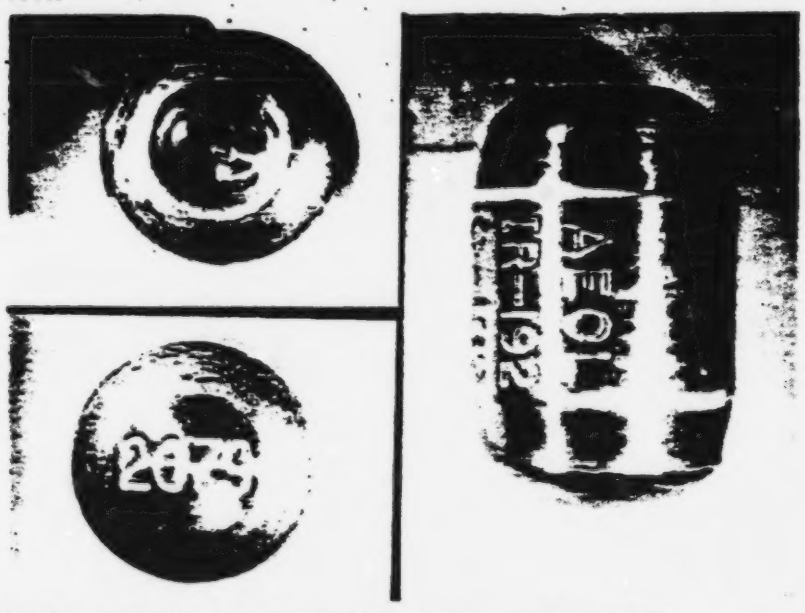
Only the bottom half of the insert was inspected for defects since the insert could not be removed from the top half (welded end) of the body. Upon UV examination, there was not any visible defects present.

DYE PENETRANT EXAMINATION - WELDED END CAPSULE

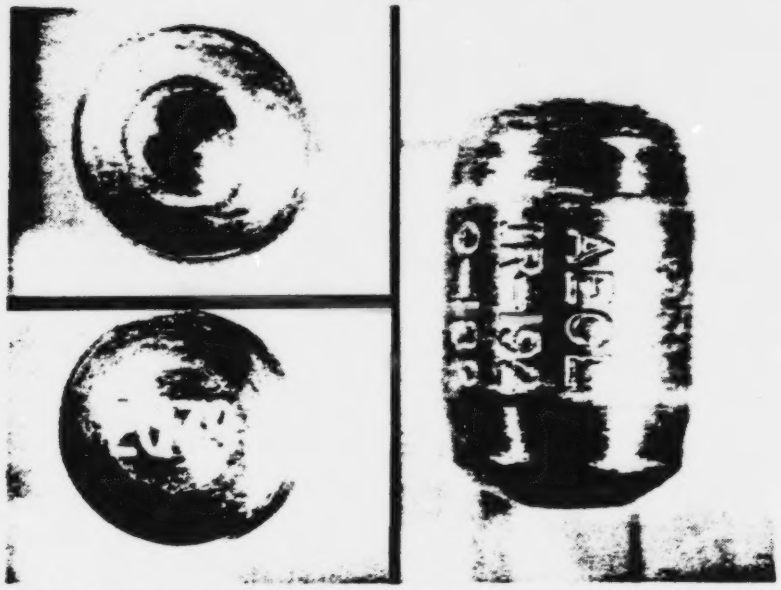
The welded end of the body was not tested for leakage of dye penetrant from the inside since the insert could not be removed.



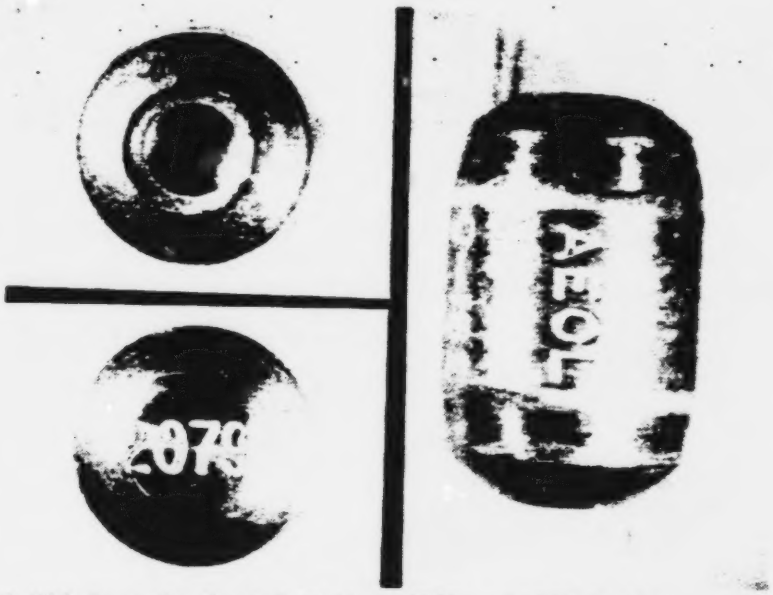
C-182 Capsule Serial Number 2079. As received.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X



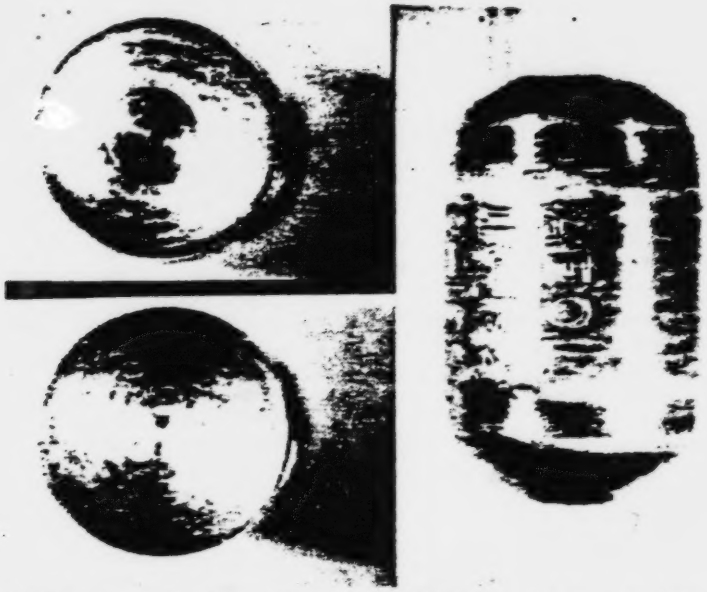
C-182 Capsule Serial Number 2079. 250 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotoraph showing welded end and side view.
4.7X



C-182 Capsule Serial Number 2079. 500 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X

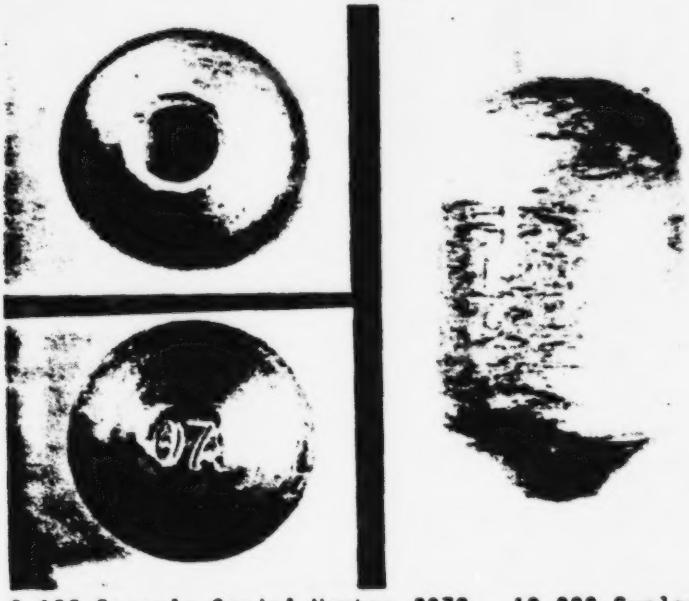


C-182 Capsule Serial Number 2079. 1,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X

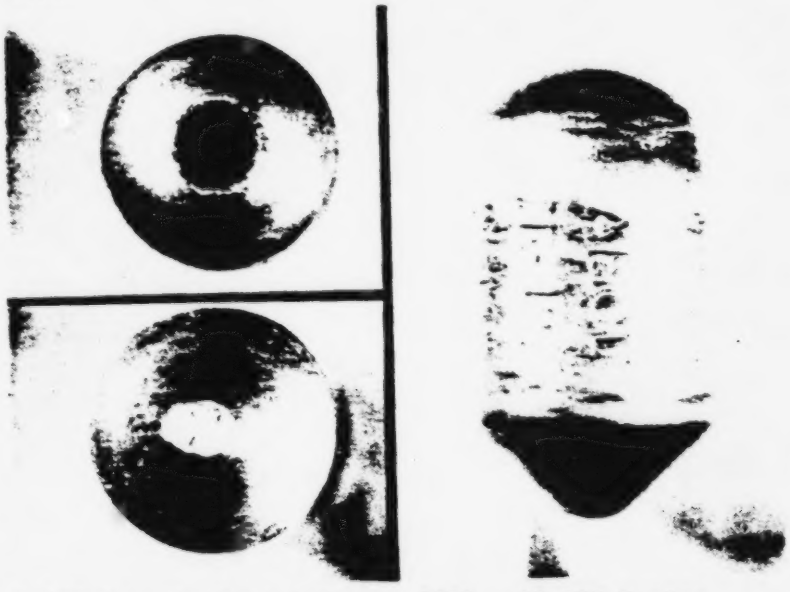


C-182 Capsule Serial Number 2079. 2,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X

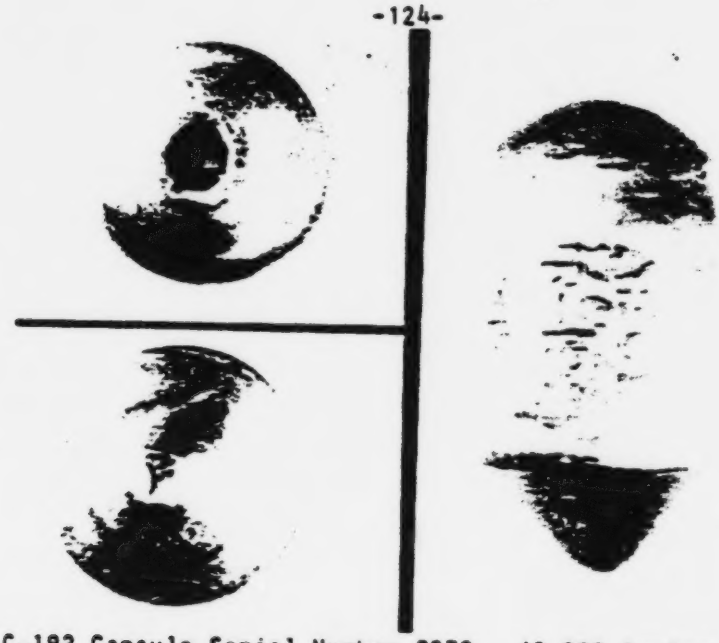
C-182 Capsule Serial Number 2079. 5,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X



C-182 Capsule Serial Number 2079. 10,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X



C-182 Capsule Serial Number 2079. 20,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X

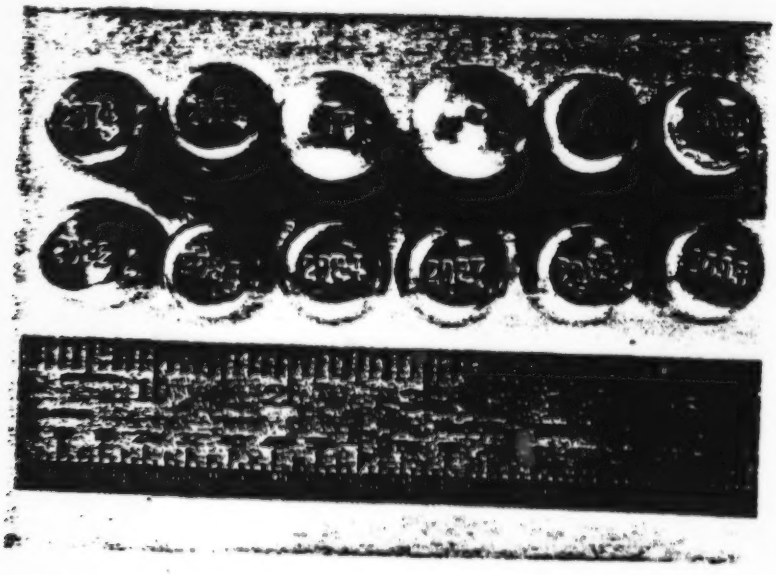


C-182 Capsule Serial Number 2079. 40,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Macrophotograph showing welded end, unwelded end, and side view.
4.7X

C-182 Capsule Serial Number 2079. 40,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Photomicrograph showing right cross-section of capsule weld area.
40X Etch: Electrolytic 10% Oxalic

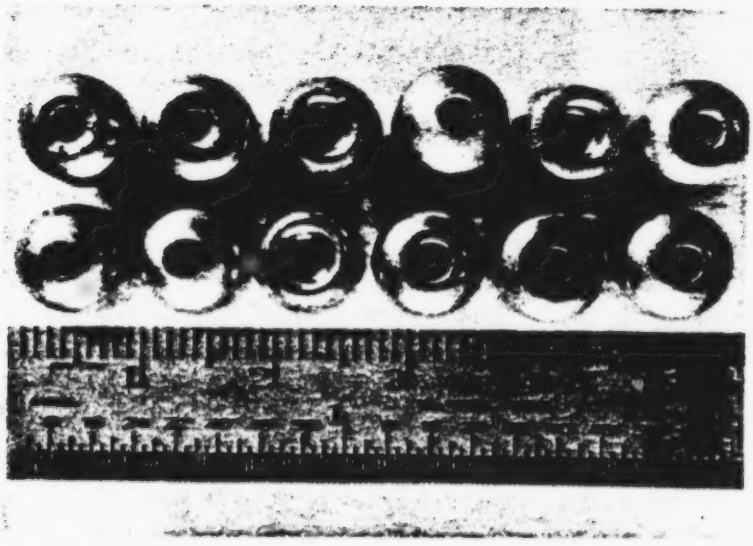
C-182 Capsule Serial Number 2079. 40,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Photomicrograph showing left cross-section of capsule weld area.
40X
Etch: Electrolytic 10% Oxalic Acid

C-182 Capsule Serial Number 2079. 40,000 Cycles.
Normal orientation and typical field operating conditions with headhose cushion removed.
Photomacrograph showing cross-section of nonwelded end of body.
12.5X



Photograph 6: Tested Capsules Nonwelded Ends.

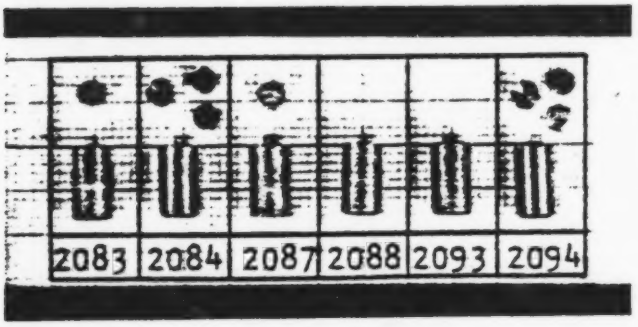
Capsule	Test Conditions
2074 -	40,000 Cycles, Normal Orientation, Typical Field Conditions
2076 -	40,000 Cycles, Normal Orientation, Typical Field Conditions
2077 -	40,000 Cycles, Reverse Orientation, Typical Field Conditions
2079 -	40,000 Cycles, Normal Orientation, Headhose Cushion Removed
2080 -	40,000 Cycles, Reverse Orientation, Pipeline Mode
2081 -	160,200 Cycles, Normal Orientation, Typical Field Conditions
2082 -	10,000 Cycles, Normal Orientation, 2-45 ^{o} Bends in Headhose
2083 -	40,000 Cycles, Normal Orientation, Maximum Air Pressure and Vacuumm, 3.05m Headhose
2084 -	40,000 Cycles, Normal Orientation, Pipeline Mode
2087 -	80,000 Cycles, Normal Orientation, Typical Field Conditions
2088 -	40,000 Cycles, Normal Orientation, Typical Field Conditions
2093 -	80,000 Cycles, Normal Orientation, Typical Field Conditions



Photograph 7: Tested Capsules Welded Ends.
Top L-R (2074, 2076, 2077, 2079, 2080, 2081)
Bottom L-R (2082, 2083, 2084, 2087, 2088, 2093)

Capsule	Test Conditions
2074 -	40,000 Cycles, Normal Orientation, Typical Field Conditions
2076 -	40,000 Cycles, Normal Orientation, Typical Field Conditions
2077 -	40,000 Cycles, Reverse Orientation, Typical Field Conditions
2079 -	40,000 Cycles, Normal Orientation, Headhose Cushion Removed
2080 -	40,000 Cycles, Reverse Orientation, Pipeline Mode
2081 -	160,200 Cycles, Normal Orientation, Typical Field Conditions
2082 -	10,000 Cycles, Normal Orientation, 2-45 ^{o} Bends in Headhose
2083 -	40,000 Cycles, Normal Orientation, Maximum Air Pressure and Vacuumm, 3.05m Headhose
2084 -	40,000 Cycles, Normal Orientation, Pipeline Mode
2087 -	80,000 Cycles, Normal Orientation, Typical Field Conditions
2088 -	40,000 Cycles, Normal Orientation, Typical Field Conditions
2093 -	80,000 Cycles, Normal Orientation, Typical Field Conditions

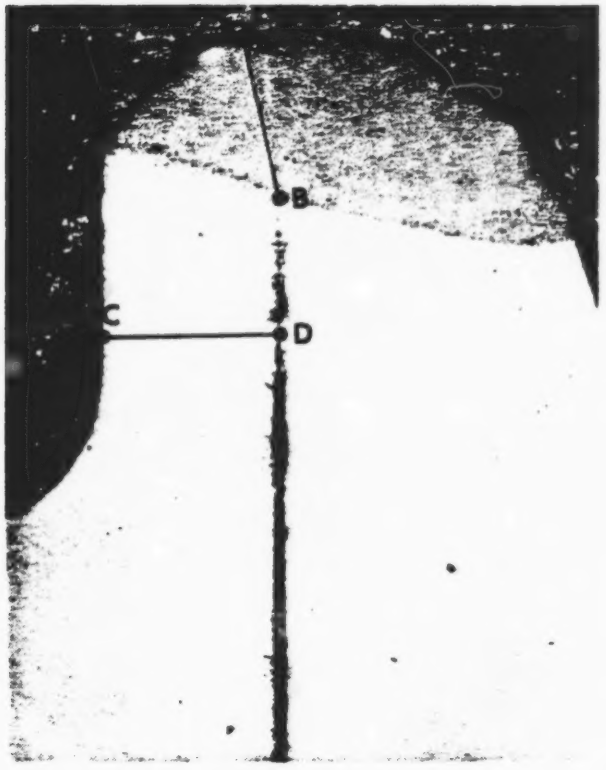
Photograph 8: Inside Contents of Tested Capsules 2074-2082
After Sectioning at Equator.



Photograph 9: Inside Contents of Tested Capsules 2083-2094
After Sectioning at Equator.

18. Weld Penetration

WELD PENETRATION CALCULATIONS



Typical Weld Cross-section

The weld penetration is expressed as a percent and is calculated by dividing the minimum weld thickness by the minimum cap wall thickness.

The minimum weld thickness is the minimum distance from the point at which the cap, body and weld intersect (A) to the outside surface of the weld (B).

The minimum cap wall thickness is the minimum distance between the two walls of the cap (eg C-D)

$$\text{Weld Penetration} = \frac{(A-B)}{(C-D)} \times 100$$

TABLE 2

WELD PENETRATION DETERMINATION

CAPSULE SERIAL NUMBER	WELD THICKNESS @ 40X (mm)	ACTUAL WELD THICKNESS (mm)	MINIMUM CAP WALL THICKNESS @ 40X (mm)	ACTUAL CAP WALL THICKNESS (mm)	WELD PENETRATION (WELD/CAP)100 (%)
2074-A	16.55	0.414	29.25	0.731	57
2074-B	19.95	0.499	28.75	0.719	69
2076-A	16.15	0.404	29.10	0.728	55
2076-B	15.75	0.394	28.70	0.718	55
2077-A	27.05	0.676	25.75	0.644	105
2077-B	26.00	0.650	26.15	0.654	99
2078-A	26.75	0.669	26.80	0.670	100
2078-B	25.85	0.646	26.20	0.655	99
2079-A	17.15	0.429	25.70	0.643	67
2079-B	16.10	0.403	26.30	0.658	61
2080-A	24.60	0.615	25.20	0.630	98
2080-B	23.45	0.586	24.50	0.613	96
2081-A	18.45	0.461	27.25	0.681	68
2081-B	18.95	0.474	27.55	0.689	69
2082-A	17.55	0.439	26.55	0.664	66
2082-B	16.95	0.424	27.25	0.681	62
2083-A	20.05	0.501	26.70	0.668	75
2083-B	17.40	0.435	26.35	0.659	66
2084-A	24.35	0.609	25.35	0.634	96
2084-B	23.55	0.589	25.55	0.639	92

WELD PENETRATION DETERMINATION (CONT'D)

CAPSULE SERIAL NUMBER	WELD THICKNESS @ 40X (mm)	ACTUAL WELD THICKNESS (mm)	MINIMUM CAP WALL THICKNESS @ 40X (mm)	ACTUAL CAP WALL THICKNESS (mm)	WELD PENETRATION (WELD/CAP)100 (%)
2085-A	22.90	0.573	25.15	0.629	91
2085-B	27.20	0.680	25.90	0.648	105
2087-A	19.50	0.488	28.50	0.713	68
2087-B	17.60	0.440	28.70	0.718	61
2088-A	18.65	0.466	28.10	0.703	66
2088-B	18.95	0.474	28.70	0.718	66
2091-A	24.00	0.600	25.80	0.645	93
2091-B	24.65	0.616	26.05	0.651	85
2093-A	17.50	0.438	28.05	0.701	62
2093-B	16.25	0.406	27.90	0.698	58
2094-A	26.20	0.655	25.10	0.628	104
2094-B	24.95	0.624	24.70	0.618	101

Note: The polished cross-section for each capsule revealed the weld in two planes, 180 degrees from each other. The weld penetration was measured and calculated for each plane. For identification purposes, the capsule serial numbers are identified with either an A or a B to indicate the left and right plane respectively.

CONCLUSIONS

The C-182 radiography capsules manufactured by Atomic Energy of Canada Limited were mechanically tested by performing a prescribed number of cycles under preset conditions in a 100-3 Pneumat-A-Ray radiography camera. The capsules were observed throughout the cycling trials and tested for changes in dimension, weight, and leakage. After completion of the prescribed cycling trials each capsule was further tested for potential leakage by dye penetrant analysis, sectioned at the equator and each half tested by dye penetrant analysis, then sectioned longitudinally, and metallurgically examined.

The results indicate that the capsules cycled under typical field conditions can become significantly deformed, and that deformation is generally related to the number of cycles that the capsules undergo. The deformation is related only to the pneumatic operation mode of the camera and the deformation occurs almost exclusively on the end of the capsule entering the camera first.

When the headhose cushion is removed then both ends of the capsule are deformed.

The only leak observed was not related to the deformed end of the capsule, but rather to the weld end of the capsule when the non weld end of the capsule was deformed from entering the cammera. The leak was shown by dye penetrant analysis and by microphotographs of the cross section of the effected capsule.

The crack appeared circumferencially around the cap of the capsule just below the weld. The leak was easily discernable when the capsule was sectioned. The presence of a crack at the undeformed end of the capsule suggests that there is a weakness inherent in the cycling method and the capsule orientation and that a combination of the two may result in a capsule failure.

APPENDIX

DRAWING 1: MODEL 100-3 PNEUMAT-A-RAY CAMERA

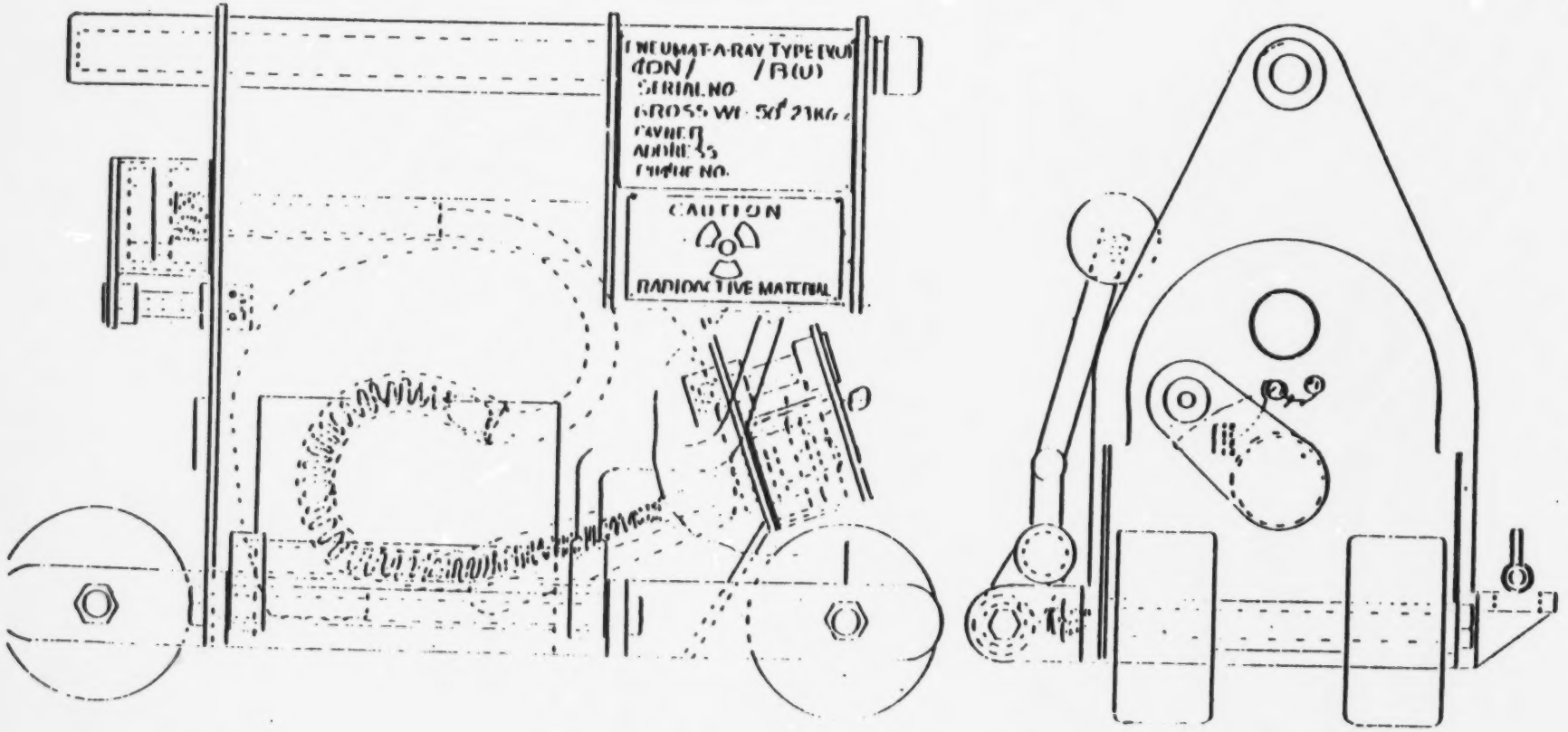


Diagram of C-182 Capsule not available for publication.